Sunref | AFD AGENCE FRANÇAISE DE DÉVELOPPEMENT

Green Building Handbook

For Building Developers & Architects

Co-funded by
EUROPEAN UNION

In partnership with
राष्ट्रीय आवास बैंक
NATIONAL HOUSING BANK

Designed By
GRIHA

Developed by: Agence Française de Développement (AFD)

Co-funded by: European Union (EU)

In partnership with: National Housing Bank (NHB)

Designed by: Green Rating for Integrated Habitat Assessment (GRIHA) Council

FOREWORD

NHB, AFD and EU came together to create this guidebook, with the support of CRISIL and GRIHA Council team. Green building guide for new building has been developed as one of the communication products, under the aegis of the Sunref India Programme. This guidebook will be useful for low- and mid-scale developers aspiring to go green in their new affordable housing projects and it will serve as a ready reference book of green and environment-friendly strategies in the affordable housing sector. It covers in detail the green building components and strategies for new and upcoming affordable housing projects. This guide provides simple and easy-to-understand strategies for all those in charge of the processes of design and construction to have a common and clear understanding of implementing green building practices.

The information provided in the green building guide will be valuable to all those who intend to learn about the various aspects that makes up affordable housing green and environment friendly. It will cover green building details related to various thematic areas and its sub-criteria. It will acquaint the reader about green building design strategies, systems, components, materials, and technologies as applicable to new developments. The idea is to create a quick checklist of easy-to-implement and cost-effective passive and active green building design strategies and solutions applicable to different stages of the building life cycle. Each thematic section contains the introduction of each theme and details on each sub-criterion, its green building strategies, and benefits.

The new green building guide includes section on the following green building themes and criteria:

- Sustainable site planning including criteria on adherence to local by-laws, promoting walkability and sustainable mode of transport, passive design strategies, preserve and protect on-site natural features, mitigate urban heat island effects, and design for universal accessibility.
- Energy management including criteria on Energy Efficiency Measures, Renewable Energy Utilization, and Use of Zero ODP and low GWP materials.
- Water conservation measures including criteria on building water management, landscape water management, rainwater management, wastewater management, and water quality.
- Solid waste management including criteria on construction and development waste management and municipal solid waste management.
- Sustainable building materials
- Occupant comfort and well-being including criteria on visual comfort, thermal comfort, acoustic comfort, and indoor environment quality.
- Socio-economic strategies including criteria on facilities for construction workers and facilities for service staff.
- Performance metering and monitoring including criteria on commissioning, metering & monitoring, and operation & management.

MESSAGES

Agence française de développement (AFD), European Union (EU) and the National Housing Bank (NHB) agreed to enter into a partnership, in July 2017, through the Sunref India Programme, aiming at supporting the development of green and affordable housing in India. This was in line with AFD's and EU's mandate in India and NHB's strategy and involvement towards a greener economy. This programme focuses on making green housing more affordable to low- and middle-income households, promoting the existing local green labels for housing, and demonstrating the market potential and relevance of green housing in the Indian context. Adopting green building practices in affordable housing sector in India would significantly create a higher positive impact on the environment.

The AFD's € 100 million credit line under the Sunref India programme is supporting the NHB's institutional capacities in the emerging green housing market. It is also supporting the NHB's refinancing operations to provide primary lending institutions (such as banks or housing finance companies) and housing developers with technical and financial assistance to facilitate the scaling up of the green affordable housing industry. Given the strategic importance of the green housing sector in India, an additional grant of € 12 million from the EU was given to reduce the cost of the credit line and support the green labelling of projects; as well as create awareness and build capacity of various stakeholders.

This guide has been developed under the aegis of the Sunref India Programme, with the intent to create a ready reference document for small/mid-size developers aspiring to go green in their new and upcoming affordable housing projects. We appreciate the efforts put in by the NHB, CRISIL and GRIHA team in developing this guidebook and are confident that it will help small/mid-scale developers in adopting green building concepts in the upcoming new affordable housing projects.

MESSAGES

European Union

EUROPEAN UNION

The Sunref India Programme has been supported by the European Union since 2017, in cooperation with the Agence Française de Development (AFD) and the National Housing Bank (NHB). Sunref aims at reducing the impact of the housing industry on the environment, through the efficient use of energy, water and building material. The European Union contributes to the programme with a grant of EUR 12 million, in addition to AFD's credit line of EUR 100 Million to the NHB. The EU grant is geared towards increasing the availability of green certified housing units for lower income households in India, working closely with housing finance companies. Furthermore, the technical skills of stakeholders are being enhanced under this project.

I congratulate AFD, NHB, CRISIL and GRIHA for this publication, which I trust will contribute towards the promotion, adoption and implementation of affordable green housing in India.

National Housing Bank

राष्ट्रीय आवास बैंक
NATIONAL HOUSING BANK

AFD launched the Sunref India Programme in partnership with the National Housing Bank (NHB), India's apex financial institution in housing finance, with support from the European Union (EU). Under this programme, banks and housing finance companies have access to competitive funding opportunities to finance green and affordable housing projects. The Bank, in 2010-11, in partnership with KfW, Germany had also launched the Energy Efficient Housing Refinance Scheme, aimed at encouraging energy efficiency in the residential sector. Green building guide for new and existing building is developed as one of the communication products, under the aegis of the Sunref India Programme. The intent of these guides is to serve as a ready reference book of green building strategies in the affordable housing sector. It covers in detail, various green building criteria applicable to new and existing housing projects and accordingly propose strategies.

We appreciate the support of AFD and EU for giving us the opportunity to implement Sunref India Programme and be a part of its success. We also thank GRIHA Council and CRIS TA for the efforts that they have put in for the development of this guidebook. We hope that this guidebook will help to enhance awareness among affordable housing developers to understand the key components and criteria of a green building concept and implement it in their existing and new projects.

CONTENTS

ABBREVIATIONS

ABS	Aerobic Biological System
ATM	Automated Teller Machine
ATS	Advanced Treatment Systems
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BLDC	Brushless Direct Current
C&D	Construction and Demolition
CFC	Chloro Fluoro Carbon
CO_2	Carbon dioxide
Cd/m^2	Candela/Square Meter
CPCB	Central Pollution Control Board
D(C)	Disinfection (Chlorine)
D(UV)	Disinfection (Ultraviolet)
dB	Decibels
EC	Electrocoagulation
ECBC	Energy Conservation Building Code
FSC	Forest Stewardship Council
GDS	Gravity Diversion System
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFO	Hydrofluoroolefin
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
KL	Kilo Litre
kW	Kilowatt
kWh/day	Kilowatt hour/day
L	Litre
L/cycle	Litre per cycle
L/flush	Litre per flush
L/min	Litre per minute
LED	Light-Emitting Diode
LPD	Lighting Power Density
MSW	Municipal Solid Waste
MW	Megawatt
NBC	National Building Code
NRC	Noise Reduction Coefficient
ODP	Ozone Depletion Potential
PDS	Pump Diversion System
PPA	Power Purchase Agreement
$PM_{2.5}$	Particulate Matter with size 2.5 microns
PM_{10}	Particulate Matter with size 10 microns
PV	Photovoltaic
RBS	Reed Bed System
RE	Renewable Energy
REC	Renewable Energy Certificate
SFS	Sand Filter System
SHGC	Solar Heat Gain Coefficient
SRI	Solar Reflective Index
Sqm	Square Meter
TV	Television
UV	Ultra Violet
VLT	Visible Light Transmittance
WC	Water Closet
WFL	Water Factor Limit
WWR	Window Wall Ratio

Accessibility: Accessibility is the characteristic that products, services, and facilities can be independently used by people with a variety of disabilities[1].

Albedo: It is the property of a material that indicates how well a material reflects sunlight. It ranges from 0 to 1 where 0 indicates that all sunlight is absorbed by the surface and 1 indicates that all the light is reflected back.

Annual Maintenance Contract: An annual maintenance contract is an agreement between a company and a provider that sets expectations for the ongoing maintenance of machinery or property that the company purchases from the provider.

Bio-Methanation: Bio-methanation is a process by which organic material is microbiologically converted under anaerobic conditions to biogas[2].

Breakdown maintenance: Breakdown maintenance is maintenance performed on a piece of equipment that has broken down, faulted, or otherwise cannot be operated.

Buildings-Related Illnesses: The diagnosable illness attributed directly to the specific air-borne building contaminants, such as Legionnaires disease, occupational asthma, etc.

Carbon Emissions: Emissions of greenhouse gases—carbon dioxide, nitrous oxide, methane, and others into the atmosphere.

Corrective maintenance: Corrective maintenance involves the replacement or repair of equipment after it fails.

Daylight Area: The superficial area on the working plane illuminated to not less than a specified daylight factor, that is, the area within the relevant contour.

Electromechanical Systems: These are systems that convert electrical energy into mechanical movements and sometimes vice versa.

Energy Intensity: The energy intensity (or embodied energy) is defined as the energy required to produce a material from its raw form, per unit mass of material produced. It is quantified for harvesting and refining processes[3].

Equity: It refers to fair opportunity for everyone to attain their full health potential regardless of demographic, social, economic, or geographic strata[4].

Fenestration: All areas (including frame) in the building envelope that let in light, including window, plastic panels, clerestories, skylight, fanlight, and glass doors that are generally more than one-half the floor height, and glass block walls.

Flood Plains: These are gently sloping areas adjacent to the rivers or water channels that get inundated during flooding.

Gender Neutral Toilets: Gender neutral toilets are bathrooms which can be used by anyone, regardless of gender.

Glare: It is the effect of brightness or brightness differences within the visual field which causes annoyance, discomfort, or loss of visual performance[5].

Glazing: The glass component of building's facade.

Global Warming Potential (GWP): GWP denoted in kg equivalent is a measure of how much energy the emissions of 1 tonne of a gas will absorb over a given period of time, relative to the emissions of 1 tonne of carbon dioxide[6].

Green Cover: Natural or planted vegetation such as shrubs and trees covering a certain area/terrain that contribute towards preventing soil erosion, keeping the environment cool and managing storm water.

Greenhouse Gas (GHG): A greenhouse gas refers to any gas that by virtue of its properties, absorbs infrared radiation, that is, net heat energy emitted from the earth's surface and re-radiates it back to the earth's surface, thus contributing to the greenhouse effect.

Hydrozone: It is the zone of landscape where vegetative species of similar water needs are grouped together.

Illuminance: At a point on a surface, the ratio of the luminous flux incident on an infinitesimal element of the surface containing the point under consideration to the area of the element. The unit of illuminance (the measurement of illumination) is lux which is 1 lumen per m^2.

Inert Waste: Inert waste is waste which is neither chemically nor biologically reactive and will not decompose or only very slowly. This has particular relevance to landfills as inert waste typically requires lower disposal fees than biodegradable waste or hazardous waste.

Infiltration/Exfiltration: The phenomenon of air leaking into (infiltration) or leaking out (exfiltration) of an air-conditioned space[7].

Landscape Waste: It consists of vegetative or organic material produced from the care and maintenance of green areas, gardens, and lawns[8].

Life Cycle Costing: It is the methodology for systematic economic evaluation of life-cycle costs over a period of analysis. It can address a period of analysis that covers the entire life cycle or (a) selected stage(s) or periods of interest thereof[9].

Light Transmittance: It is the measure of percent of visible light transmitted through a glass pane which depends on the type of body substrate and coating done on glass.

Lighting Fixture: The component of a luminaire that houses the lamp or lamps or positions the lamp, shields it from view, and distributes the light. The fixture also provides for connection to the power supply, which may require the use of ballast[10].

Lighting Power Density: The maximum lighting power per unit area of a building classification of space function[11].

Lighting Uniformity Ratio: Ratio between 0 and 1 indicating the uniformity in the intensity of lighting in the workplace. The higher the ratio, the more uniform the lighting and the more comfortable the visual environment.

Luminaire: It is a complete lighting unit consisting of a lamp or lamps together with the parts designed to distribute the light, protect the lamps, and connect the lamps to the power supply[12].

Luminance: The quotient of the luminous intensity in the given direction of an infinitesimal element of the surface containing the point under consideration by the orthogonally projected area of the element on a plane perpendicular to the given direction. The unit is candela per square meter
(cd/m^2)[13].

Luminous Efficacy of a Light Source: It is the ratio of the total luminous flux emitted by the source to the total power input to the source. Luminous efficacy is expressed in lumens/Watt[14].

Maintenance: This involves work that is carried out to preserve assets to enable their continued use and function.

Mean Radiant Temperature: The uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body is equal to the radiant heat transfer in the actual non-uniform enclosure[15].

Net Positive Energy Building: A building that on an average over the year produces more energy from renewable energy sources than it imports from external sources.

Net Positive Water Building: A building that replenish more water than it uses.

Noise: Unwanted sound which may be hazardous to health interferes with communications or is disturbing[16].

Occupancy Sensor: A device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be regulated accordingly[17].

Ozone Depletion Potential: A relative capability of a refrigerant or a gas to degrade ozone in the atmosphere as compared to trichlorofluoromethane [R-11 or chlorofluorocarbon-11(CFC-11)]. The ozone depletion potential (ODP) of CFC-11 is taken to be 1.0[18].

Passive Design: The design that takes advantage of climate to maintain a comfortable temperature range in space. Passive design reduces or eliminates the need for auxiliary heating or cooling.

Pit Composting: It refers to the biological decomposition of organic waste such as food or plant material by bacteria, fungi, worms and other microorganisms in controlled aerobic (in the presence of oxygen) conditions to produce compost.

Preventive Maintenance: It is a part of an operation and maintenance process, which is done to avoid system breakdown and enhance the life of the system.

Regularly Occupied Areas: Building space intended for continuous human occupancy. Such space generally includes areas used for living, sleeping, dining and cooking, but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.

Run-off Coefficient: It is a dimensionless factor that is used to convert the amount of rainfall to run-off. It represents the integrated effect of catchment losses and depends upon the nature of land surface, slope, degree of saturation, and rainfall intensity[19].

Shutdown Maintenance: Shutdown Maintenance is maintenance that can only be performed while equipment is not in use.

Skylight Roof Ratio: The ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof[20].

Skylight: A fenestration surface having a slope of less than 60° from the horizontal plane[21].

Smart Meter: It is typically an electronic equipment that records and stores energy consumption data in intervals of an hour, minute, or less. It further communicates the stored information at least daily back to the utility for monitoring and billing purposes.

Solar Heat Gain Coefficient: The solar heat gain coefficient (SHGC) is the fraction of incident solar radiation admitted through a fenestration, both directly transmitted, absorbed and subsequently released inwards through conduction, convection and radiation[22].

Solar Reflective Index: The index is a measure of the ability of constructed surface to reflect solar heat as shown by a small temperature rise.

Thermal Capacity: The thermal capacity of a body is the heat necessary to raise the temperature of the body by one degree.[23]

Urban Heat Island: It is created when an urban area or metropolitan area is significantly warmer than its surrounding rural areas due to human activities.

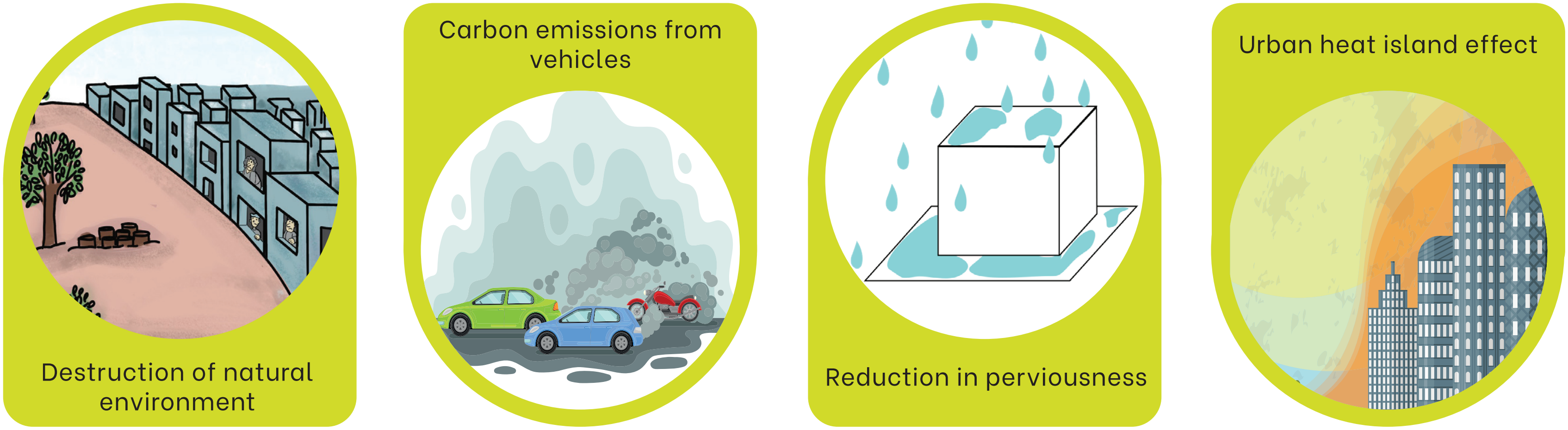
Ventilation: The process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned[24].

Visible Light Transmittance (VLT): The ratio of the total transmitted light to the total incident light.

Window-to-wall Ratio: Ratio of the glazed surface area to the exterior wall surface area.

1 SUSTAINABLE SITE PLANNING

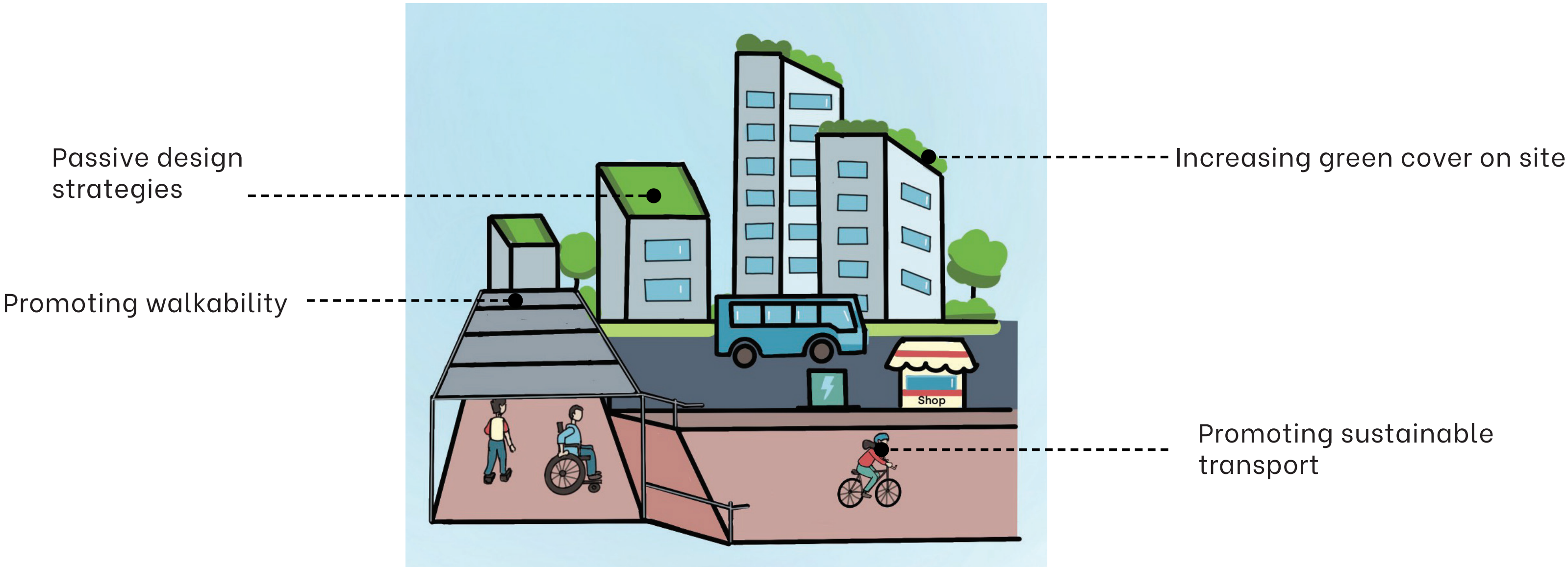
Rapid urbanization and population growth have contributed to unsustainable development of cities. This has led to a steep decline in green bodies, destruction of natural habitats and resources, increase in carbon emissions from transport, reduced perviousness and increased fossil fuel based energy consumption. All these factors contribute towards creation of heat islands effects in urban areas.



Outcomes of unsustainable urban development

WAYS TO ENSURE SUSTAINABLE SITE PLANNING

Site selection and planning is the first step to a sustainable habitat and needs to be carried out appropriately prior to commencement of the design phase. Strategies for sustainable site planning include adherence to local by-laws and development guidelines, use of passive design strategies, implementing strategies to increase green cover on site, promoting walkability and sustainable transport in and around the site, and ensuring universal accessibility on site.

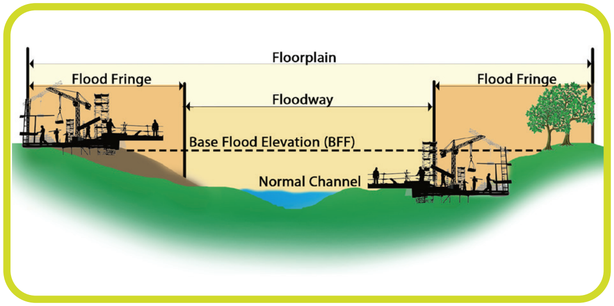


Strategies for sustainable site planning

1.1 ADHERENCE TO LOCAL BYLAWS

Local by-laws play an important rule in preventing haphazard development and land use patterns, hence ensuring the maintenance of urban biodiversity and microclimate. Some important factors to consider as per local by-laws are ground coverage and height of the development, per capita open area to be left on site, local zoning laws, eco-sensitivity zones, heritage area laws etc.

Haphazard construction

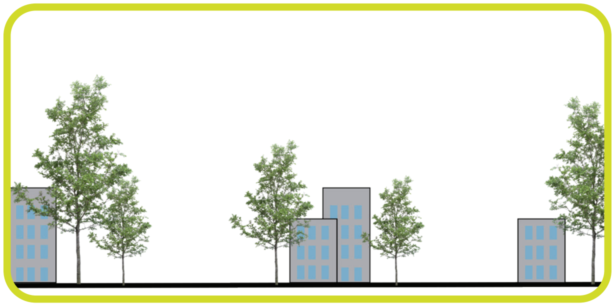


Construction in flood plains /eco-sensitive areas leading to loss of lives and properties

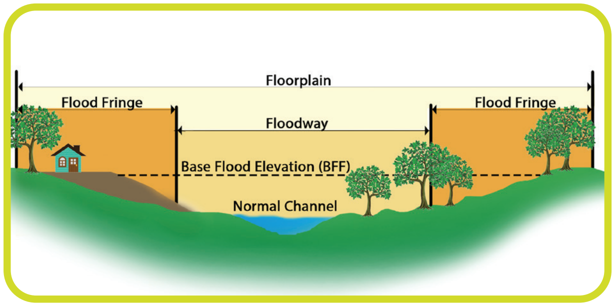
Outcomes of unplanned constuction

Conformity to local by-laws of eco-sensitive zones

Conformity to local by-laws of existing heritage buildings



Conformity to per capita open area as per local by-laws



Conformity to local by-laws of coastal region

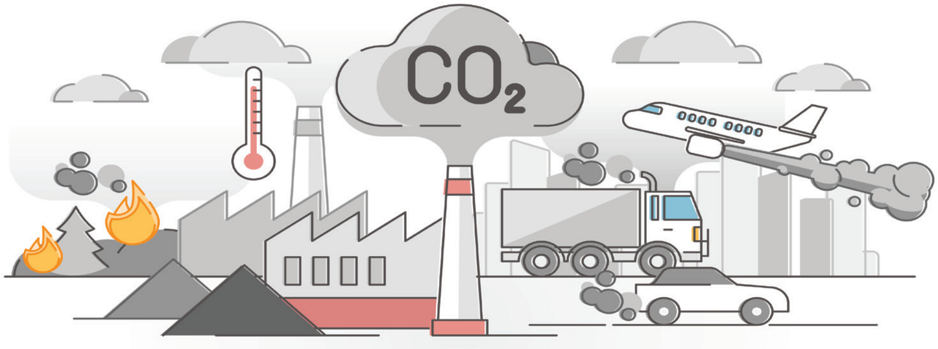
Few strategies to ensure site selection and planning

REMEMBER!

Building must have all relevant permits as per local by-laws. Some examples of NOCs that a project must obtain before / after commencement of construction are: Fire NOC, Environmental clearance certificate, NOC from the Airport Authority of India, Occupancy Certificate etc. For full list of approvals, refer Annexure I.

1.2 PROMOTE WALKABILITY AND SUSTAINABLE MODE OF TRANSPORT

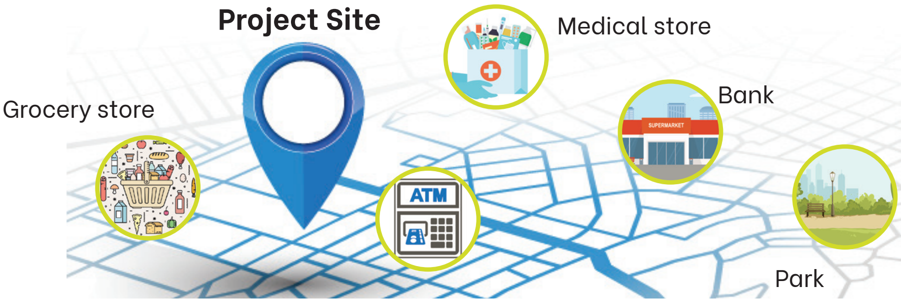
Carbon emissions from transport are one of the largest contributors of air pollution and greenhouse effect which causes the temperature of Earth to rise. To decrease these emissions, it is crucial to reduce our dependency on private vehicles, by encouraging public transport and walkability.



Carbon emissions due to transport

WAYS TO PROMOTE SUSTAINABLE TRANSPORT

Planning the site such that it provides easy access to public and sustainable transport reduces carbon emissions due to transport. Creating proper infrastructure such as charging points for e-vehicles for cyclists to cater to the needs of people using sustainable modes of transport is key to minimize dependency on private vehicles.

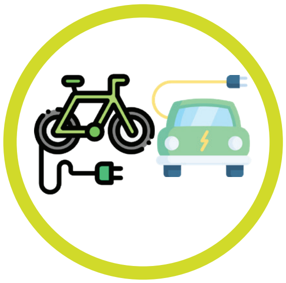


Ensure proximity to basic amenities

Incorporate auto stands/e-rikshaw stops/bus stands within the site for better connection to public transport.

Provide a shuttle service from the housing complex to nearby public tranport.

Provide cycle stands on site to promote environmentally friendly methods of transport.



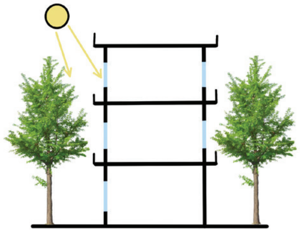
Provide dedicated spots for E-vehicle recharge for 2 wheelers and 4 wheelers.

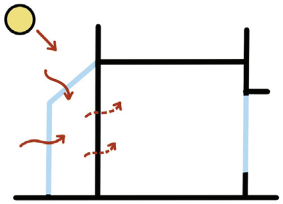
1.3 PASSIVE DESIGN STRATEGIES

Passive design strategies optimize building's thermal performance and reduce construction and operational cost in a project. Incorporating passive design strategies that are contextual to the building results in reduced dependency on mechanical systems to improve building performance. The key to design a passive building is taking advantage of the local climate (microclimate) and site condition whilst minimizing the negative impact of construction. Climate characteristics such as humidity, wind velocity etc can help with identifying approaches at the site planning stage.

SHADING USING VEGETATION

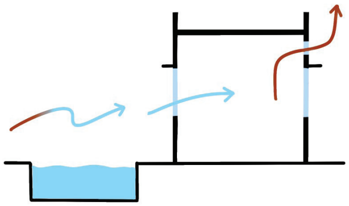
Trees of appropriate species and types can be used to protect buildings upto G+3 floors from harsh sun and wind.





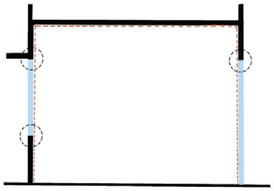
SOLARIUM

A solarium or a sunroom is a south-facing glass room coupled with the building in cold climates. It acts as a greenhouse and heats up the main building.



EVAPORATIVE COOLING

Water temperature is cooler during the day when the air temperature is high. Hence a water body near buildings helps to pre-cool air when entering from outside.

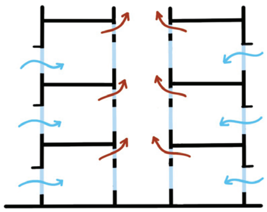


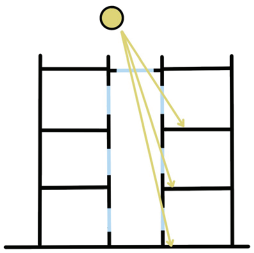
AIRTIGHTNESS

Heat loss through cracks and joints can be avoided by maintaining good quality construction and sealing doors and window frames properly.

STACK EFFECT

When an atrium is provided in a building, an escape is provided for the hot air to rise up, hence inducing air movement inside the building. This phenomenon is called the stack effect.





USE OF ATRIUM

Direct solar radiation enters the atrium through the glass roof and is reflected throughout the atrium as well as in the internal spaces in the building. This passive strategy helps in increasing heat gain in the building as well.

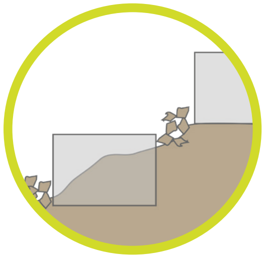
Examples of passive design strategies

1.4 PRESERVE AND PROTECT ON-SITE NATURAL FEATURES

Environmental context of any site includes its existing site features such as existing water bodies, green belts, soil and landscape, biodiversity and contours. Altering existing natural site features can lead to concerns like urban flooding, contamination of water bodies, increase in urban heat island effect, disruption of natural wind patterns leading to poor ventilation and many more.

Destruction of Biodiversity

Contamination of Water Bodies



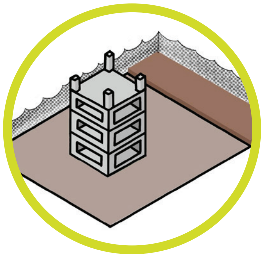
Destruction of Natural Contours

DID YOU KNOW?

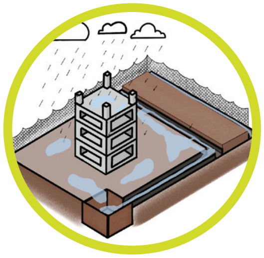
It takes ateast 100 years for the top soil to be formed depending upon factors such as climate and vegetation[25].

STRATEGIES TO PRESERVE ON-SITE NATURAL FEATURES

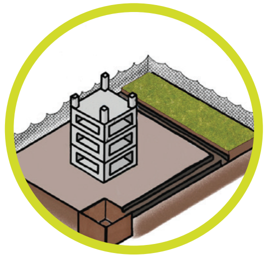
Scrape off the top 10'' of soil (if the soil is fertile) before beginning excavation.



Store the top soil in an undisturbed location in not more than 40 cm high stacks, or Spread/store the topsoil in areas that are planned for landscaping.

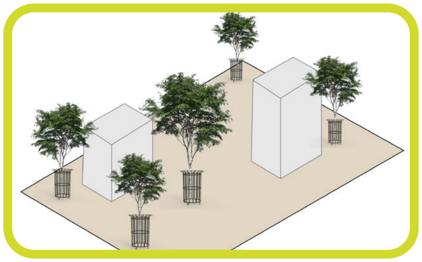


Construct temporary soil erosion channels around the periphery of the soil storage area to trap the soil and prevent it from flowing along with the run-off water during monsoon.



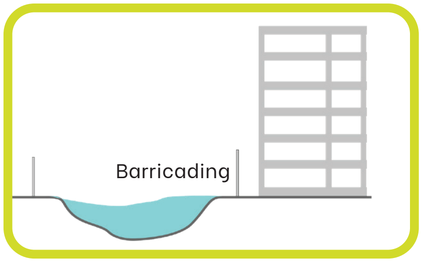
Practice mulching to preserve the fertility of topsoil.

Existing Tree Preservation



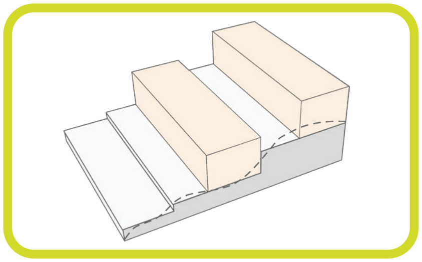
Preserve trees by barricading them during construction / transplant them to a safer location on site.

Existing Water Body Conservation



Ensure existing water bodies on site are preserved and protected from any C & D waste.

Contour Preservation

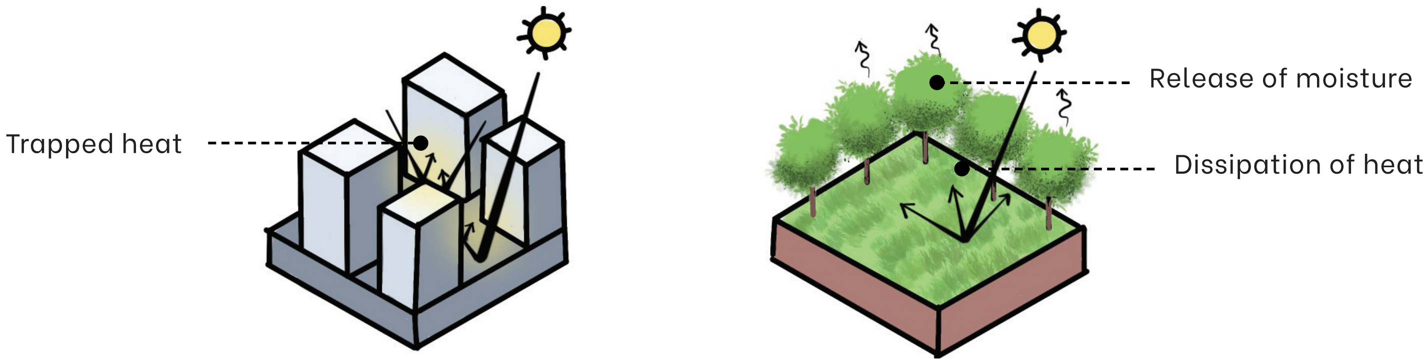


Construction should be carried out along the natural contours of the site.

REMEMBER!
Do not cover stored topsoil with an impermeable material. Do not store hazardous materials near the top soil.

1.5 MITIGATE URBAN HEAT ISLAND EFFECT (UHIE)

Due to rapid urbanization and infrastructure development, tree and vegetative cover have declined with an increase in built up area. The urban areas consist of materials such as concrete, asphalt, and stone that have high thermal capacities and low albedo. This causes higher night-time air temperature in cities, hence contributing to urban heat islands in these areas. On the other hand, rural areas with more vegetative cover remain cooler as the vegetative species provide shading and release moisture to keep the environment cool. Research shows that cities are generally 3-10 degrees hotter than rural areas.

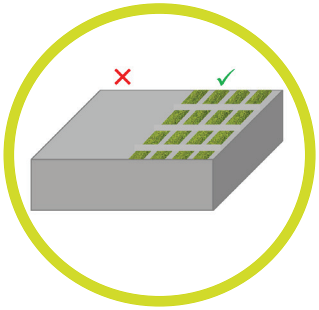


Heat dissipation in urban and rural environments

STRATEGIES TO MITIGATE UHIE

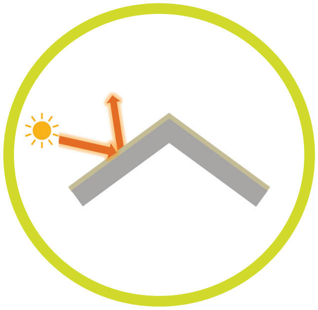
Strategic designing and right material selection can help in reducing the peak ambient air temperature on site significantly. This can be achieved by minimizing use of heat-absorbing hard paving materials such as concrete especially in unshaded areas like the roof and exposed pavements, providing appropriate shading / tree cover in exposed areas on site and using highly reflective materials.

Reduce hard surfaces



Site area around the building must be planned to minimize unshaded hard surfaces that absorb direct solar radiation and donot allow water to percolate into the soil. Soft paving like grass concrete pavers and greenery should be used.

Use of high Solar Reflective Index paints



High SRI paints/tiles should be used in exposed roofs, roads, pavements and exposed walls.

Provision of shading

Shading on exposed areas like paved areas / roof, by means of structures such as pergolas and solar PV panels ensures that heat is not absorbed by the surfaces hence limiting the rise in surface temperatures.

Provision of green cover

Providing green cover not only shades the site, but also helps lower down ambient air temperature by means of evapotranspiration.

2 OCCUPANT COMFORT AND WELLBEING

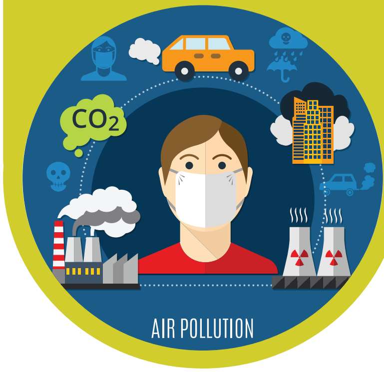
Construction of new buildings has made huge impact on our economy, environment, health and productivity. Negative impact of environment can be reduced if green design measures are implemented as an integrated part of the design and construction process. Buildings should be designed to ensure occupant comfort and health issues that can arise due to poorly designed buildings as mentioned below:

Extreme temperatures and humidity can cause discomfort sensations and stress

Noise Pollution from inside and outside the building can cause stress, high blood pressure, speech interference, hearing loss, and sleep disruption.

Improper lighting levels can cause eye-strain, fatigue, headaches, stress and accidents

Threatening pollutants can lead to a higher risk of respiratory illnesses, and various chronic conditions.

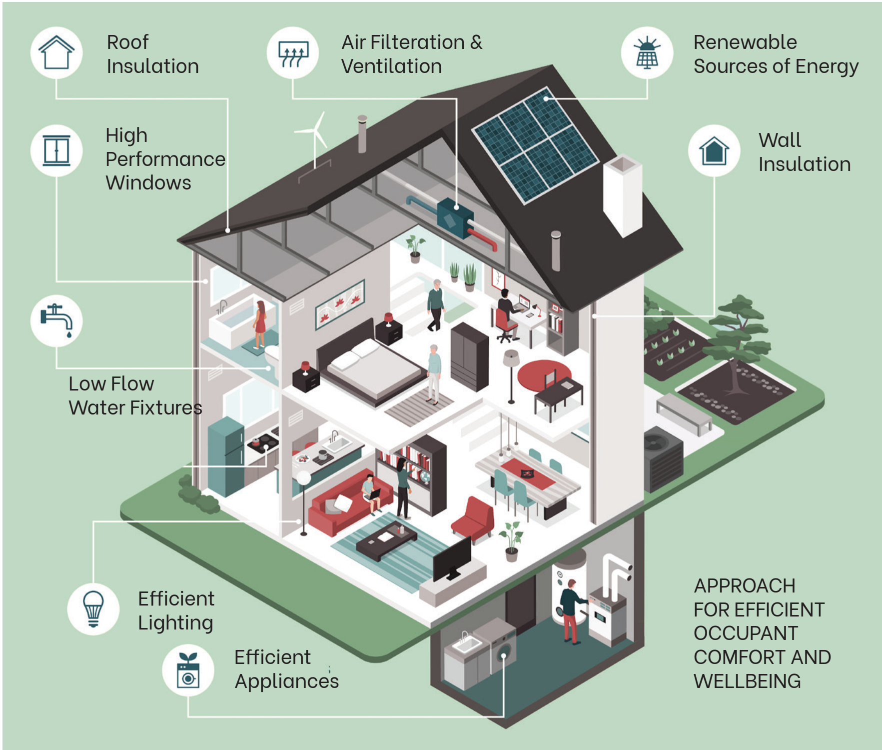


APPROACH FOR EFFICIENT OCCUPANT COMFORT AND WELLBEING

A green design incorporates environmentally friendly and energy-saving measures into its design process. It also adds to the durability of the buildings and improves the comfort level and health of its occupants.

Following are the primary parameters that can enhance occupant comfort and wellbeing:

- Thermal Comfort
- Visual Comfort
- Acoustic Comfort
- Indoor Air Quality

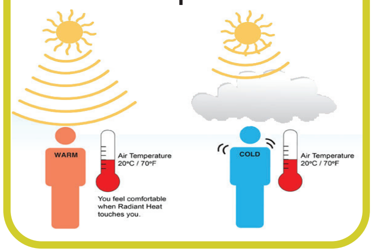


2.1 THERMAL COMFORT

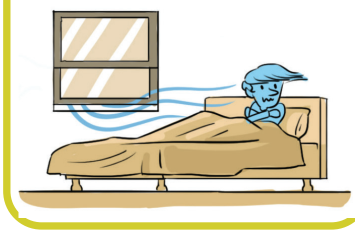
Thermal comfort is defined as that condition of mind which expresses satisfaction with the thermal environment. Human thermal comfort is a combination of a subjective sensation (how we feel) and several objective interactions with the environment (heat transfer rates) regulated by the brain[26].

The primary environmental factors for addressing thermal comfort are mentioned below:

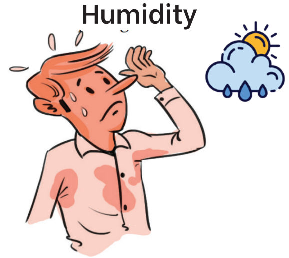
Air Temperature



Air Speed



Humidity

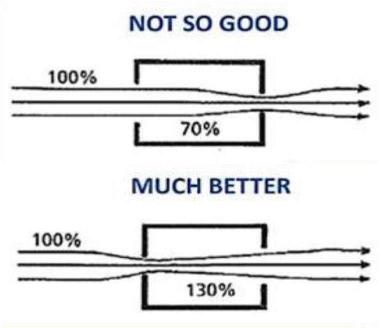


Radiant Temperature

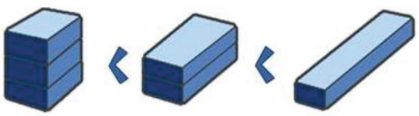
HOW TO ACHIEVE THERMAL COMFORT IN BUILDINGS?

Architectural design features including form, orientation, shape etc. strongly affect the indoor thermal conditions of built space. Indoor thermal conditions up to a certain extent can be improved by judicious selection of building components, optimum orientation of building layout and proper selection of shading devices.

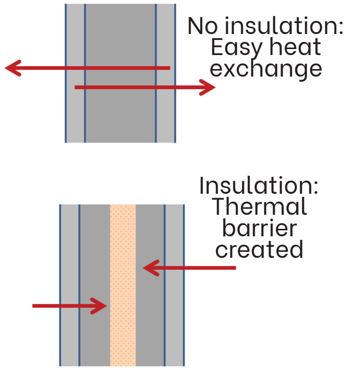
Design Recommendations



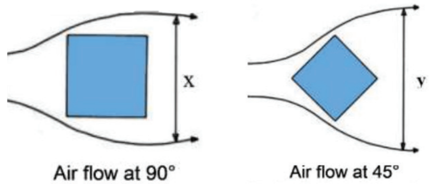
1. The air inlet openings should be smaller than the outlet openings



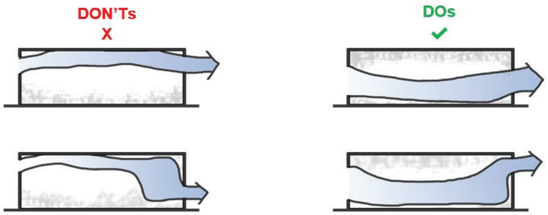
2. Increase compactness by reducing surface area (S) for the same volume (V). Low S/V ratio for cooling dominated regions



3. Introduction of insulation in walls and roofs helps in minimizing heat exchange. This can be helpful in both hot and cold climates



4. Building orientation should allow unobstructed air flow



5. To allow for better cross ventilation, air inlets and outlets should be placed across the room, but should not be placed directly opposite to each other

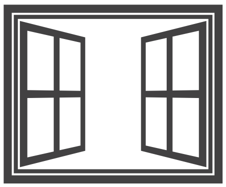
2.2 VISUAL COMFORT

Visual comfort in a building is perceived as the occupants satisfaction due to the quantity and quality of light in the building specific to the task being performed. Factors affecting visual comfort are: Outside view and quantity-quality-uniformity of light.

Visual comfort in a building

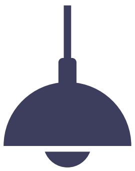
Fenestration
- Outside View
- Daylight

Artificial Lighting
Acts as substitute of daylight



Visual comfort or discomfort can be assessed by measuring the illuminance level[27]

REQUIREMENTS	SPACES	RECOMMENDED ILLUMINANCE (LUX)
Low	Living	100-150-200
Moderate	Bedroom/dining	100-150
Moderate to High	Study/reading/kitchen counter	200-300-500



HOW TO ACHIEVE VISUAL COMFORT IN BUILDINGS?

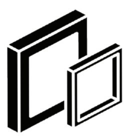
During daytime when natural light is available in abundance, a window can be utilized as a tool to harness natural light from outside to light an indoor space. Visual comfort during the day time can be achieved by optimizing the daylight inside a building.

Parameters affecting the availability of daylight in buildings:

Latitude

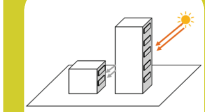
Building orientation, & massing

Fenestration size

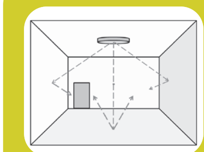


Fenestration glass

Shading



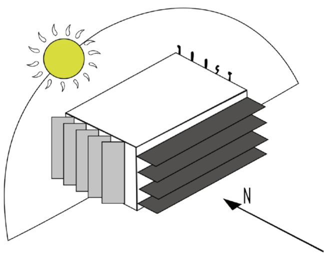
Building: obstruction & surface



Internal surface reflectance

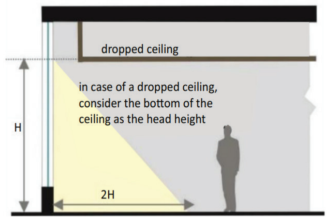
Suggested strategies to achieve visual comfort:[28]

Shading



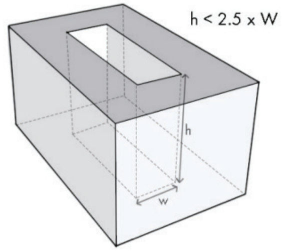
Horizontal Shading on N/S facade and vertical shading on E/W facade

Daylight Zone



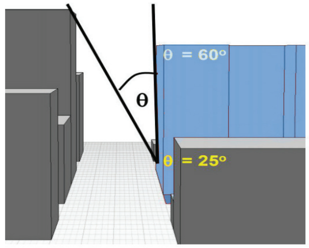
The depth of daylit zone is typically 1.5–2 times the window head height

Atrium Height



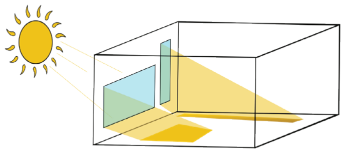
The maximum atrium height should be about 2.5 times its width to have daylight interior spaces

Sky Angle



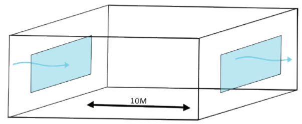
By determining the sky angle, the daylight potential of the building's facade can be calculated

Window Shape



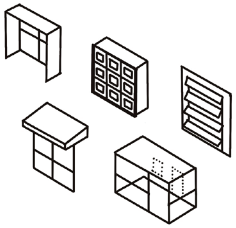
Taller windows provide greater penetration while broader windows allow better distribution of light

Window Placement



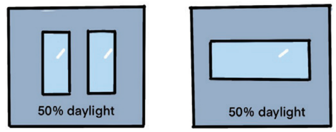
If the room depth is more than 10 m, windows should be provided on opposite sides for bilateral lighting.

Window Opening



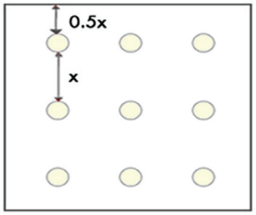
Different types of horizontal and vertical shading used to reduce solar heat gain.

Optimization of WWR and Glass Selection



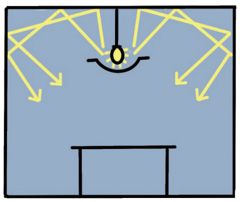
Trading off WWR and glazing for best VLT values to maximize daylight & minimize glare

Luminaire Placement



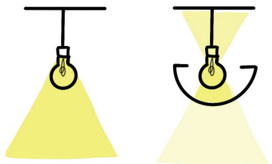
The luminaires are spaced x metre apart where distance of the end luminaire from the wall is 0.5x metre

Indirect Lighting



Indirect lighting creates a low glare environment by uniformly lighting the ceiling

Screening & Shielding



Screening & shielding the sources from direct view or covering with diffusing plates to reduce glare

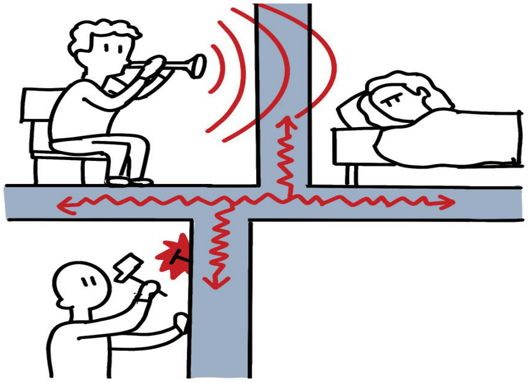
Light surfaces

About 7% improvement in lighting levels can be achieved with light or white wall finishes

2.3 ACOUSTIC COMFORT

Sound is created by waves of compressed air that we perceive with our ear. The sound can be transmitted through air and through building fabric, the healthy human ear is sensitive to frequency ranging from around 20Hz to 20,000 Hz. The distinction between loud and quiet sounds is made by the difference in scale of the pressure changes commonly measured in decibels.

The sound can be transmitted through air and through building fabric.



NOISE LEVEL FOR THE REGULARLY OCCUPIED SPACES IN RESIDENTIAL AREA[29]

Spaces	Day (dB)	Night (dB)
Living	45	35
Bedroom	40	30

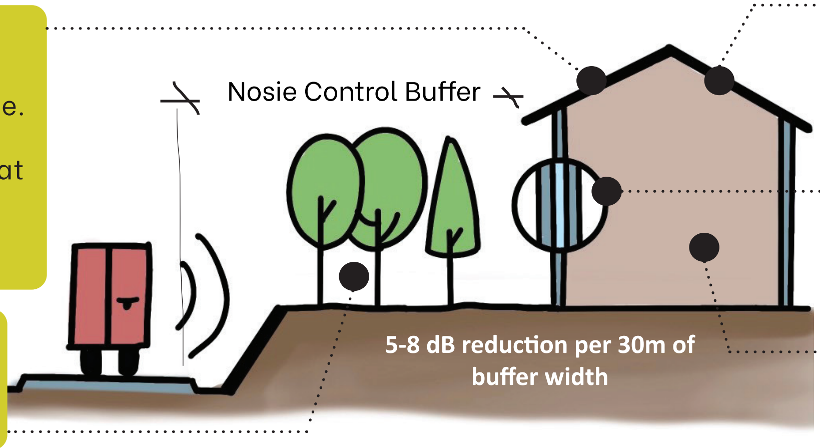
AVERAGE dB LEVELS & POSSIBLE RESPONSE TO COMMON SOURCES OF NOISE[29]

Activity	Average Sound Level Estimate (dB)	Typical Response
Normal breathing	10	Typically Safe
Clock ticking	20	
Soft whisper	30	
Refrigerator hum	40	
Air-conditioning, normal conversation	60	
Washing machine, dishwasher	70	Mild annoyance possible
City traffic noise	80-85	Annoyance likely
Motorcycle	95	Hearing loss possible after prolonged exposure
Approaching train, car horn at 5 m	100	Hearing loss possible after short exposure
Concerts, nightclubs, very loud stereo or TV	105-110	
Firecrackers	140-150	Hearing loss likely

HOW TO ACHIEVE ACOUSTIC COMFORT IN BUILDINGS?

It is advised to use high Noise Reduction Coefficient NRC materials for better performance. The (NRC) is a single number value ranging from 0.0 to 1.0 that describes the average sound absorption performance of a material.

Creating barriers and breaks between sources of noise



Use acoustic tiles on ceilings and walls with NRC value above 0.5 to dampen the sound

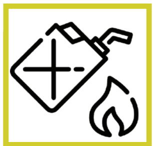
Improve the building airtightness to enhance the indoor acoustic comfort

Optimize room shape and size to reduce echoes and reverberation

2.4 INDOOR AIR QUALITY

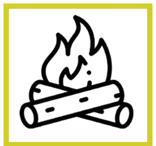
Indoor and outdoor pollution sources both that release gases or particles into the air are the primary cause of indoor air quality problems in homes. Improving the air quality inside the building is essential for occupants well-being and comfort. To achieve quality air, the flow of the air should be monitored and facilitated.

Sources of Pollution:


Combustion of fuel

Air & Dust Pollution


Landfills

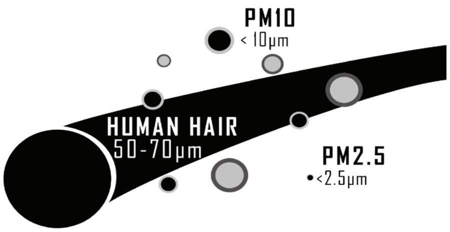

Combustion of Wood


Burning of Waste


Industrial Waste

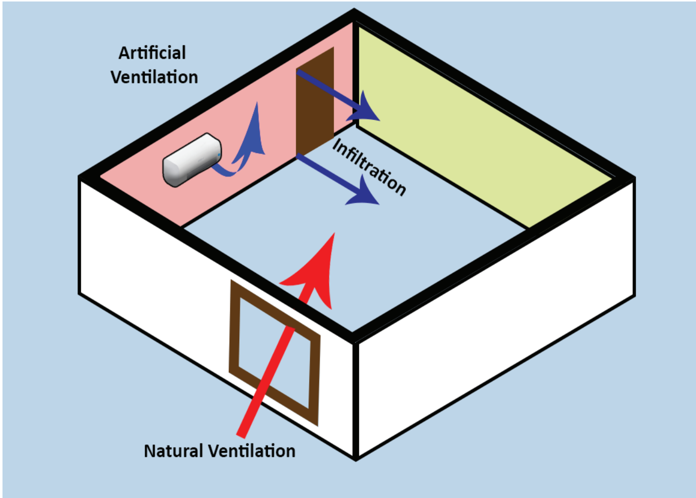
The particulate matter i.e. PM_{10} and $PM_{2.5}$ often derived from different emissions sources, have different chemical compositions. When the level of these particles increases and penetrate deeply in to the lungs, one can experience number of health impacts like breathing problem, burning or sensation in the eyes etc.

Size of $PM_{2.5}$ and PM_{10}:



Outdoor air enters and leaves a house by:

A. Infiltration
B. Natural ventilation
C. Mechanical ventilation



HOW TO IMPROVE INDOOR AIR QUALITY IN BUILDINGS?

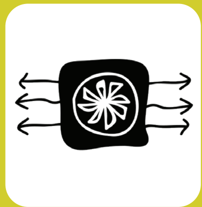
Suggested strategies for improved IAQ in residential space:


Planting of indoor plants and trees at site that improves the quality of air


Provide separate shafts for kitchen and toilets for proper air circulation


Installation of separate exhaust system for kitchens and toilets

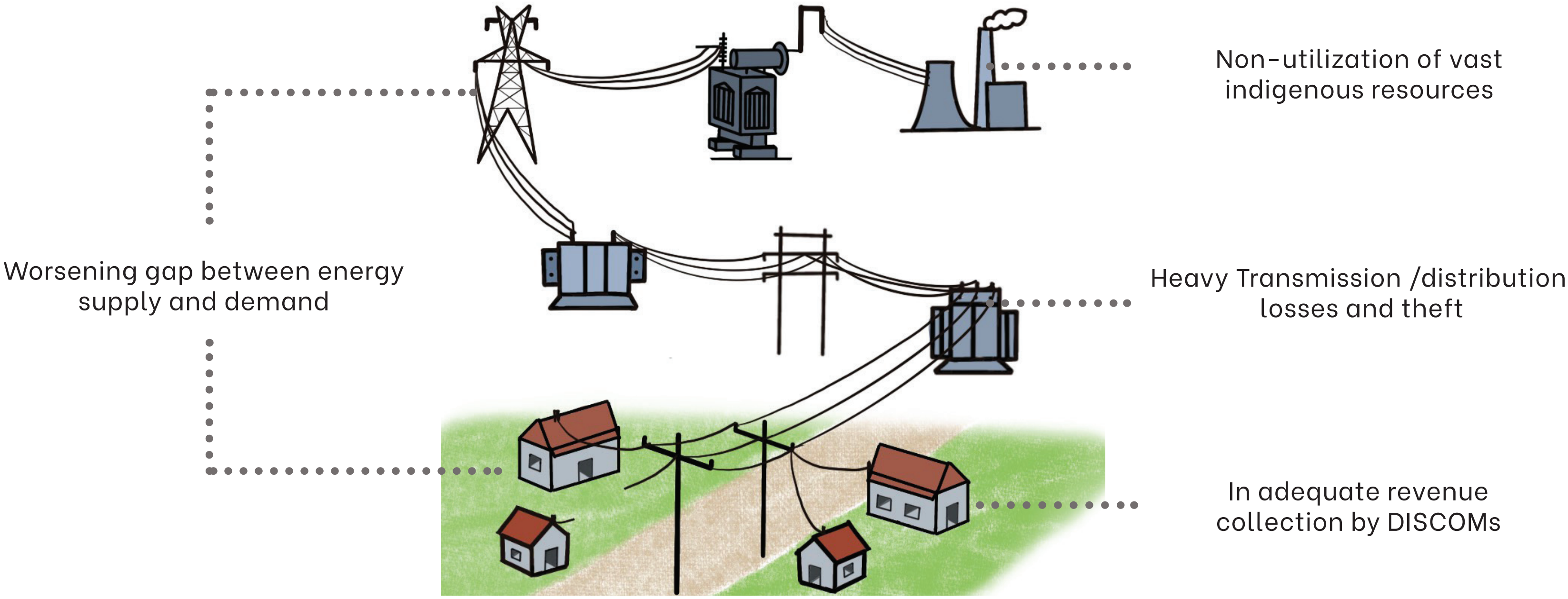

Installation of air curtains


Air sanitization (Filteration of microbes, isolation systems etc.)


Dedicated smoking zones/area at a distance of 8-10 meters

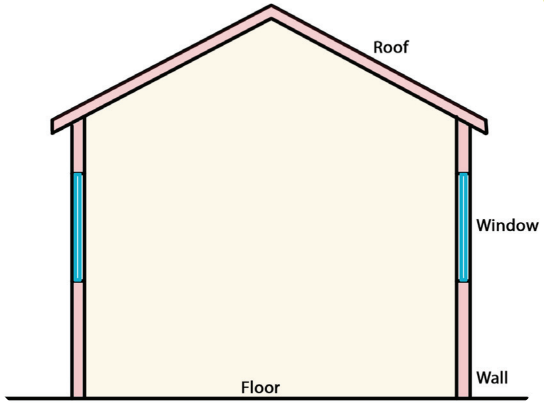
3 ENERGY MANAGEMENT

Energy management is a process by which a project team can effectively manage energy produced and its control, monitor and conserve as much energy as they can while also generating enough energy to meet the demand of the consumer.

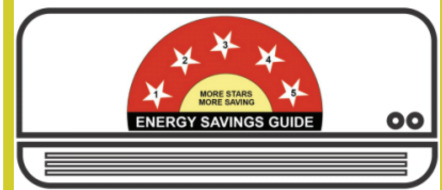


Energy Management and its challenges

STRATEGIES FOR EFFICIENT ENERGY MANAGEMENT AT PROJECT LEVEL



Step 1 - Optimize Building Envelope Design

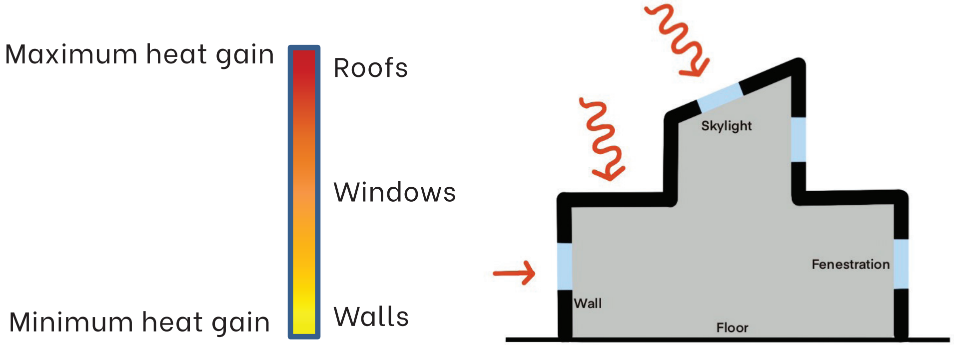


Step 2 - Installation of Efficient Fixtures and Equipment

Step 3 - Utilization of Renewable Energy resources for reduced energy demands.

3.1 ENERGY EFFICIENCY MEASURES

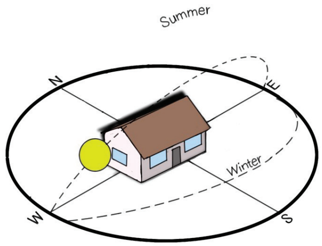
Energy efficiency in a building is the reduction in energy demand per unit of floor area. This can be primarily achieved by having efficient building envelop design and by use of energy efficient lighting, equipment and appliances.



Heat transfer through different building elements

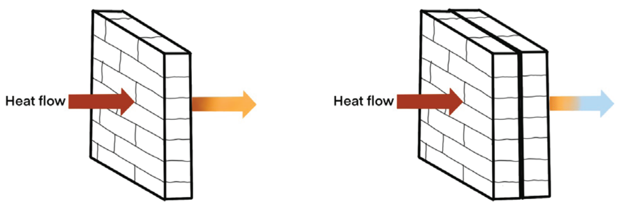
HOW TO OPTIMIZE BUILDING ENVELOPE

Orientation: Maximum heat gain occurs through East and West directions during morning and evening hours respectively, followed by South and North.



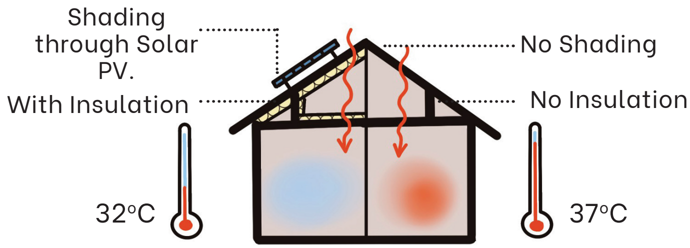
Spaces that require heat gains should have longer facades oriented towards east and west. Spaces that do not require heat gain should have longer facades oriented towards towards north and south.

Walling: Selection of walling materials on its U-value and its thickness helps in managing the heat gain.



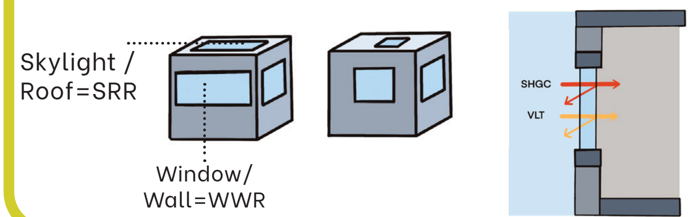
Heat flow through thicker walls is slow.

Roof: Greater thickness of roofs delays heat entering the building. Insulations should be provided over rooftops. Shading of roofs should be done to reduce gains.



Fenestrations:

Window to Wall Ratio - Lower WWR results in lesser heat gains.
Skylight to Roof Ratio – Lower SRR results in lesser heat gains from roof.
Solar Heat Gain Coefficient – Lower SHGC results in lesser heat gains through windows.



For more destails refer Annexure II

3.1 ENERGY EFFICIENCY MEASURES CONTD.

LIGHTING DESIGN

There are three important steps to remember while optimizing lighting design in a building: Selection of efficient lighting fixtures, placement of lighting fixtures and provision of lighting controls lighting efficiency can be defined by two parameters. Lighting Power Density (LPD) and Luminous Efficacy.

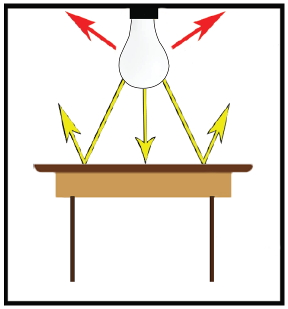
Lighting Power Density[31]

It is the maximum lighting power per unit area of a space as per its function or building as per its classification.

Spaces	LPD W/m^2
Stairways	5.50
Corridor/transition	7.10
Parking / Driveways	3.00
Lobby	9.10

Luminous Efficacy

Outdoor lighting should have lamp efficacy greater than 80 lumens / watts. BEE star labelling program rates LED luminaires on the basis of luminous efficacy.

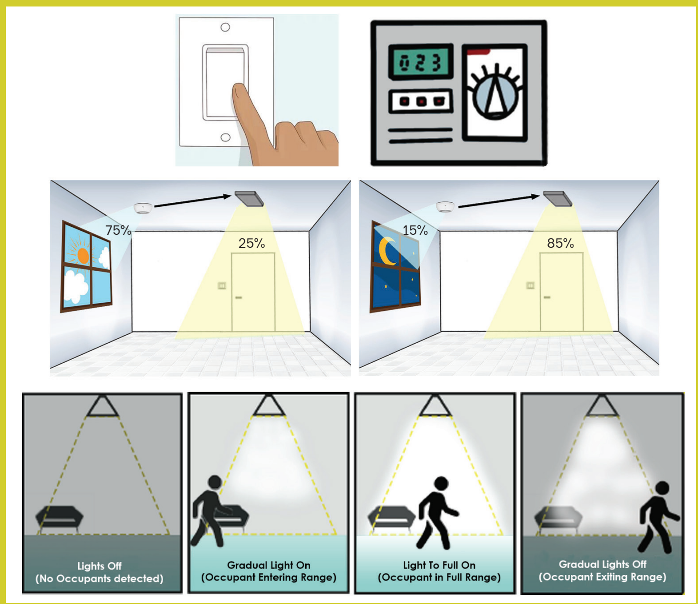


OPTIMIZE LIGHTING DESIGN IN BUILDING

Placement of lighting

One of the important aspects of designing lighting systems is to determine the position of the luminaires.

- Indoors – Lighting should be placed such that it falls uniformly over all areas and have uniformity ratio of 0.4 or more[32].
- Outdoors - Average level of illumination on surface in lux should be between 30 to 4 lux for important traffic routes and secondary roads with light traffic respectively. Additionally, cone of light should be maintained for uniform lighting[33].



Different types of lighting control
a) Manual Controls; b) Timer Controls; c) Daylight Sensors; d) Occupancy Sensors

Lighting controls

Different approaches can be used to control indoor and outdoor lighting. A few type of controls are:

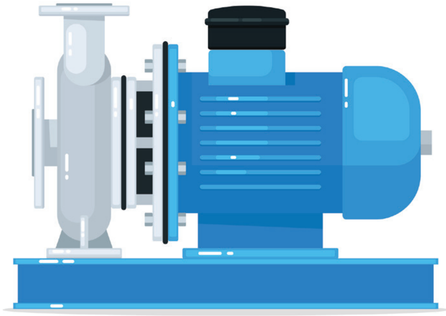
- Scheduling the Control: It uses a time scheduling device to control lighting systems.
- Occupancy Sensors: It controls lights in response to the presence or absence of people.
- Daylighting controls: It switches or dim electric lights in response to the presence or absence of daylight.
- Manual controls: These are provided to manage lights in building as per demand.

EFFICIENT APPLIANCES AND EQUIPMENT

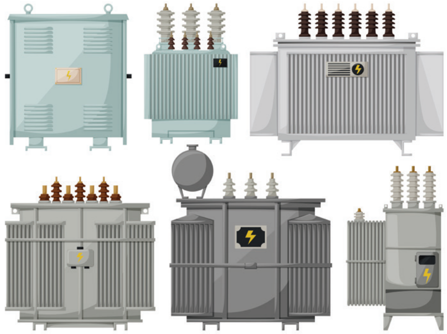
Energy efficient appliances and equipment use technologies that are less energy intensive to reduce the amount of electricity used per product. Most commonly used appliances in new buildings are fans, transformers and motors.

Fans

Motors



Transformers

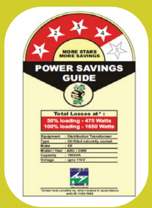


Common types of electric equipments installed in new buildings

THINGS TO CHECK BEFORE BUYING APPLIANCES

Fans

Option 1: Fans with BEE star rating can be installed in the project. BEE rates fans based on their energy efficiency and performance. The rating is on the scale of 1 to 5 stars, 1 being the least efficient and 5 being the most efficient.



Option 2: If not opting for a BEE star rated
Lesser wattage
Higher Airflow
Energy efficient technology (BLDC)

Motors

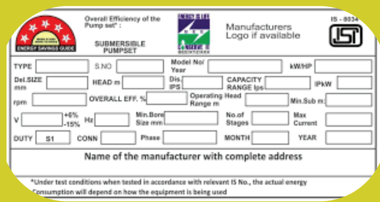
Option 1: Motors with BEE star rating can be installed in the project.

Option 2: The efficiency of motors selected should be as per ECBC which has been derived from IS code.

Class type	Class number
Standard efficiency	IE1
High efficiency	IE2
Premium efficiency	IE3
Super premium efficiency	IE4

Transformers

BEE does the star labelling of the transformers based on load losses.



In distribution system, major losses occur due to long distance between the transformer and connected system.
Power transformers must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating as per ECBC.

3.2 RENEWABLE ENERGY UTILIZATION

WHAT ARE RENEWABLE FORMS OF ENERGY?

Renewable energy, often referred to as clean energy, is generated from natural sources or processes that are constantly replenished. Example, sunlight or wind. Their availability depends on time and weather. Generating energy from a renewable source helps in reducing air pollution and does not produce green house gases as compared to fossil fuel based generation.

TYPES OF RENEWABLE ENERGY SYSTEMS

Solar Energy

Solar energy can be generated using photo voltaic and solar heaters for electricity generation and water heating respectively. It can be used in two ways: heating and/or for generating electricity.

Wind Energy

Wind turbines help in generating energy from wind and are most useful in areas with high wind potentials such as costal areas.

Hydro Power

Hydro power generated due to flow of water, can be sourced from:

- Micro Hydro (Onsite)
- Large Hydro either use plants for both or none (Offsite)

Bio Energy

Bio energy is generated from organic waste, which can be used to produce

- Heat,
- Electricity

SELECTION OF RENEWABLE ENERGY SYSTEM (ONSITE)

Solar Energy

Solar Photo Voltaic:

- Area required/kW – $10m^2$
- Energy generation /kW – 3 to 4 kWh / day
- Cost / kW – ₹70,000 to ₹1,00,000

Solar water heating:

- Area required/kW – 2m2 per 100 LPD.
- Energy generation /kW – 1500 kWh/ year / 100 LPD
- Cost / kW – `20,000 to `25,000 per 100 LPD capacity

Wind energy

Wind energy depends on:
Wind speed (main factor)
The area swept by the blades
Air density

Wind speed:

- Minimum wind speed 12-14 km/h.
- Ideal wind speed 50-60 km/h
- Maximum wind speed 90 km/h.

Hydro Power

Small hydropower usually generate up to 100 kW of electricity.

Selection of Micro hydro plant depends greatly on site and terrain.

Small hydro is divided into 3 segments:

- Micro (100kW or below),
- Mini (101kW-2MW)
- Small hydro (2-25MW)

Bio energy

- Biomass / Kg of gas - 20 to 30 kg of Biomass per Kg of gas.
- Depends on availability of biomass (Food waste, animal excreta etc.)
- Can be used as cooking fuel (Biogas), electricity (combustion engines and pyrolysis) and alternative fuel (Ethanol)

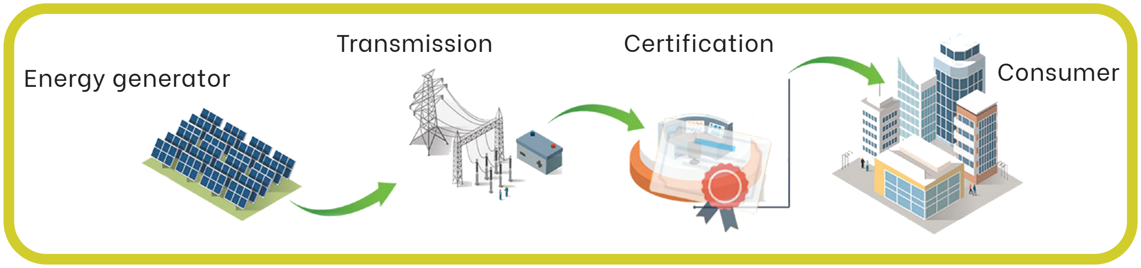
3.2 RENEWABLE ENERGY UTILIZATION CONTD.

WHAT IS OFFSITE RENEWABLE ENERGY?

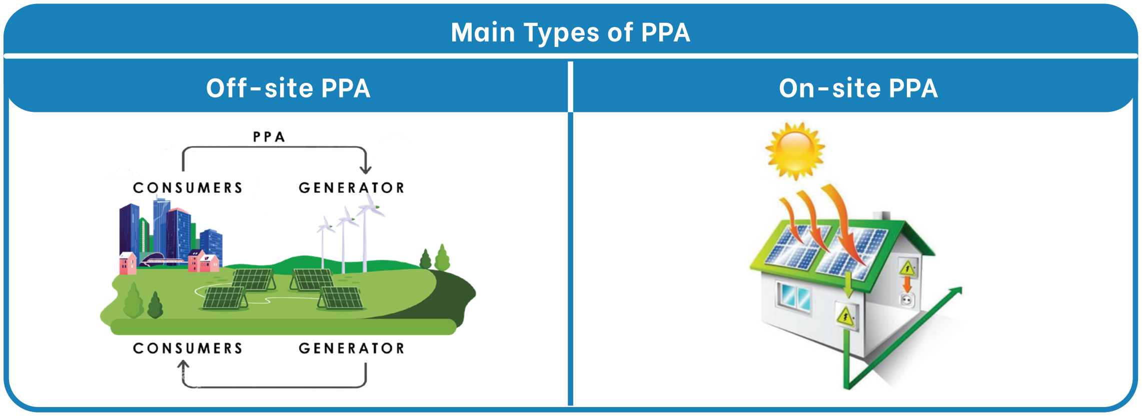
Offsite renewable energy is the technology application where renewable energy system is not present at the building location. This may be due to non availability of space, building and land ownership restrictions, or financial constraints.

OPTIONS AVAILABLE IN MARKET FOR OFFSITE R.E. APPLICATION

Renewable Energy Certificates - Renewable Energy Certificate is market-based instrument that certifies that the bearer owns one megawatt-hour (MWh) of electricity generated from a renewable energy resource. REC can be purchased from Indian Energy Exchange from various providers.



Power Purchase Certificate- A (PPA) is a legally enforceable contract signed between a buyer and seller of electricity. The buyer can use this to their benefit by leasing out their land to energy seller to setup a renewable energy plant after which energy generated from plant could be purchased at a discounted rate from the seller. This mode is very favorable for small scale projects as the initial capital investment is very low.



HOW TO MAKE THE RIGHT CHOICE?

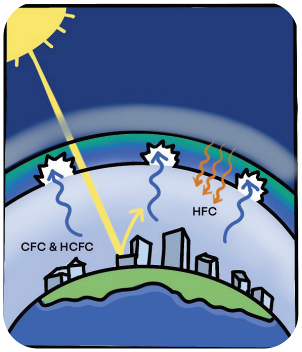
On-site and Off-site renewable energy choices should be made on initial cost investment and quantum of energy offset. Both can be pursued by the developers based on these factors.

Off-site	On-site
Small cost savings compared with buying ‘standard’ electricity from your electricity retailer.	Better return on investment because savings are across the whole electricity supply chain
Most or all of electricity can be sourced from renewables.	Percentage of electricity that can be generated in this way is small, usually from 5-30 % of total consumption.

3.3 USE OF LOW ODP AND GWP MATERIALS

Harmful gases and materials cause atmospheric degradation such as ozone layer depletion, climate change etc. Two important properties of building and system materials causing degradation of atmosphere are:

Ozone Depleting Potential– It is the of ability of a substance to degrade the ozone layer.



Global Warming Potential – It is the ability of a substance to trap heat in the atmosphere.

HOW TO SELECT ZERO ODP AND LOW GWP MATERIALS?

These gases and chemicals are primarily used in different building equipment such as refrigerants, insulation (manufacturing materials) and firefighting equipment.

Fire fighting equipments

While selecting fire fighting equipment ensure that they are free from Halon. Commonly used halon-free fire extinguishers are as follows:

- Water fire extinguishers
- Foam fire extinguishers
- Powder fire extinguishers
- Wet chemical fire extinguishers
- Carbon dioxide fire extinguishers

While selecting refrigerators and air conditioners look for equipment that have natural or low GWP refrigerants such as R-32, C-Pentane etc.

Common material with ODP and GWP value[34]

Material	Usage	ODP value	GWP value
R 12 (CFC)	Refrigerant	1	10,900
R 22 (HCFC)	Refrigerant	0.055	1810
R 32 (HFC)	Refrigerant	0	675
R 134a (HFC)	Refrigerant	0	1430
R 1234yf (HFO)	Refrigerant	0	4
CO_2 Base	Fire Extinguisher	0	1
Dry Powder	Fire Extinguisher	0	N.A.

Insulation

While opting for building and equipment insulation opt for natural insulation materials, such as Rockwool, Glass wool, passive design measures like air gaps between the layers of building elements such as walls contribute significantly towards insulating the interiors. If selecting foam insulation make sure they are free from ODP and GWP gases.

4 WATER MANAGEMENT

With the ever growing rate of water consumption, urban India is facing a severe water crisis. Overutilization and lack of treatment and reuse of wastewater is causing a continuous depletion of ground water and contamination of ground and surface water. Lack of proper storm water management is not just leading to shrinking of fresh water sources, but is also leading to urban flooding which, has become the most prevalent phenomenon in cities.


Over exploitation of water bodies

Water depletion

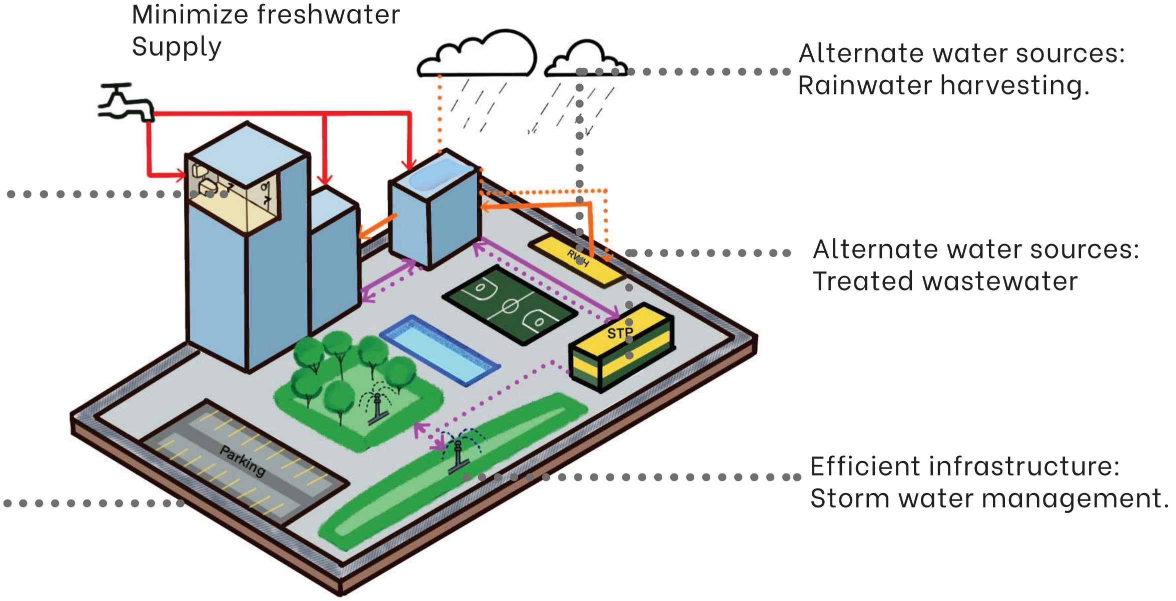


Urban flooding due to poor infrastructure

Water contamination

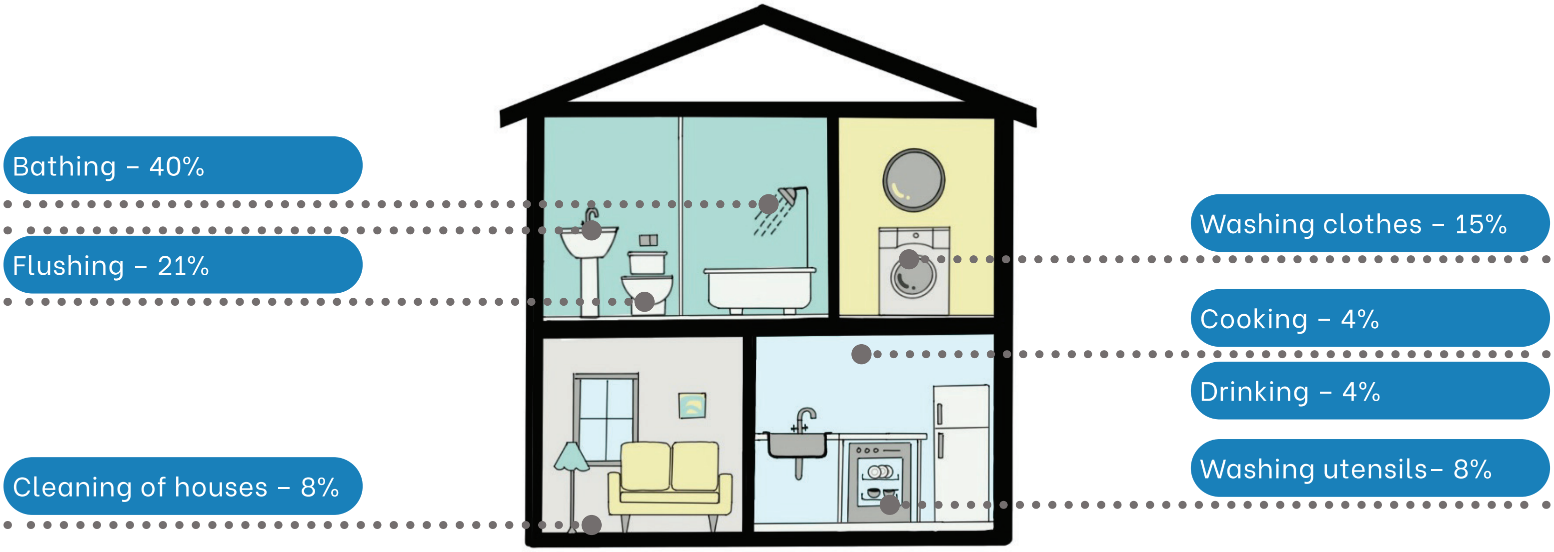

THREE POINT APPROACH FOR EFFICIENT WATER MANAGEMENT

To ensure efficient water management, a three fold approach must be adopted, including reducing building and landscape water demand, utilizing alternate sources of water and designing infrastructure to prevent flooding and to restore groundwater. Additionally, the quality of water used for various purposes must be maintained as per relevant standards.



4.1 BUILDING WATER DEMAND REDUCTION

Building water demand in a household constitutes of water required for drinking, cooking, bathing, washing clothes and utensils, cleaning and flushing. Since these tasks are essential for day to day activities, installing efficient plumbing fixtures is the most effective solution to minimize building water demand.



Typical water demand in a household highlighting the percentage of average domestic water consumption.

HOW TO MEASURE THE EFFICIENCY OF PLUMBING FIXTURES?

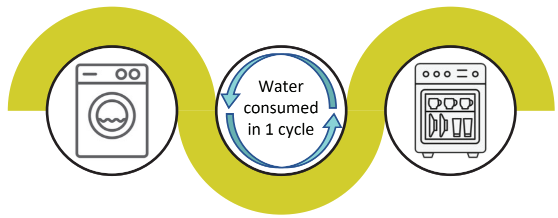
A plumbing fixture that serves its purpose (cleaning/bathing/washing etc.) with lesser amount of water can be considered as efficient plumbing fixture. Efficiency of any plumbing fixture can be measured by its flow rate or water factor limit (WFL).

FLOW RATES: Amount of water that passes through a specific fixture per unit time / per use. Greater the flow rates, lower is the efficiency of the plumbing fixture.

For WCs and urinals, flow rates are measured in Liter/flush.

For faucets and showerheads, flow rates are measured in L / min.

WATER FACTOR LIMIT: Amount of water consumed (in gallons) by a dishwasher or washing machine to complete one full cycle. WFL is measured in Liters/ cycle or gallons/ cycle.



The lower the WFL, lower is the water consumption, hence more efficient is the equipment.

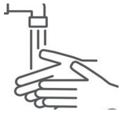
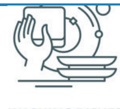
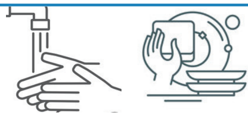
REMEMBER!
Information about flow rates and water factor limit is easily available in the product brochure / specification sheets. Don't forget to compare flow rates and WFL of different products to choose the most efficient one!

4.1 BUILDING WATER DEMAND REDUCTION CONTD.

Type of plumbing fixture	Conventional flow rate	Standard flow rate as / NBC[35]	Low flow plumbing fixtures
	15L	6L	<2L
	7.5-11L	3.8L	<2L
	Upto 25 L/min	8L/min	<2L/min
	Upto 25 L/min	10 L/min	<4.5 L/min

Installing low-flow water faucets and fixtures can help reduce water consumption by 30%-40%.

Note: Installing low flow fixtures on the top most floors (in gravity fed systems) where height between the tank and plumbing fixtures is less than 5m is not advisable as the flow rates in such spaces is already low.

Types of low flow faucets	Flow rates	Applications
Mist Flow Pattern 		
Shower Flow Pattern 		
Foam Flow Pattern 		

Types of aerators and their applications

Water-saving aerators for faucets maintain a constant rate of water flow as they minimize variation in the flow due to pressure fluctuations. These are equipped with mesh screens that divide the flow of water into multiple small streams by adding air in between. The volume of water flowing from the tap gets reduced as the water stream is diluted with air. This results in water savings on faucets.

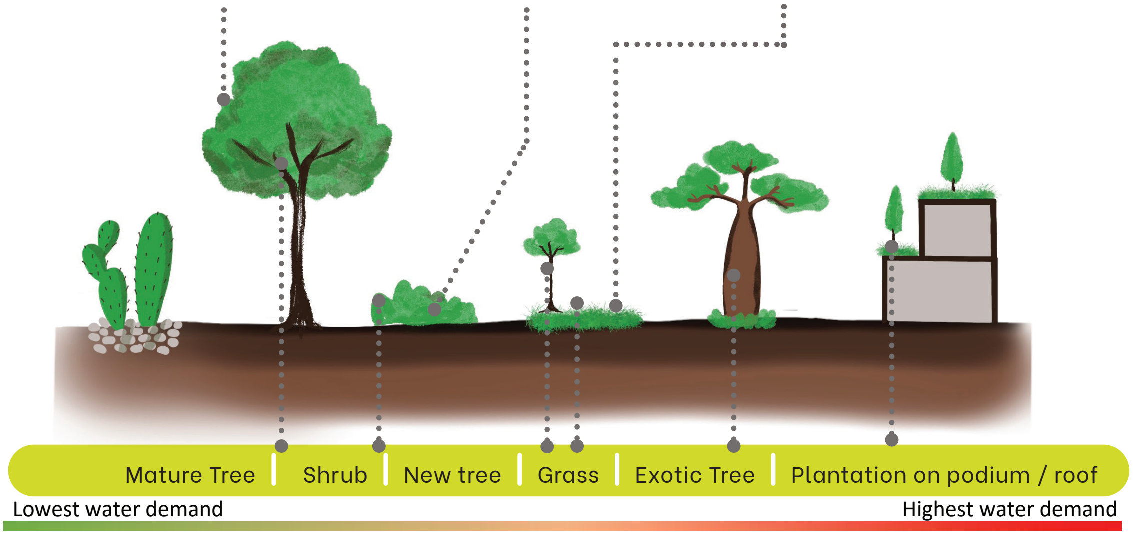
An aerator can help reduce the flow rate of a faucet from 15 L/min to about 2-4 L/min. Different kinds of aerators can be used for different activities depending on the flow pattern desired for the activity.

4.2 LANDSCAPE WATER DEMAND REDUCTION

An efficient landscape design not only reduces the water consumption of a project, but helps mitigate environmental hazards like urban flooding and urban heat island effect. The key strategies to reduce the landscape water demand in any project are the design of landscape and use of efficient irrigation systems.

EFFICIENT LANDSCAPE DESIGN STRATEGIES

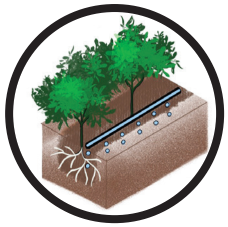
1. **XERISCAPING**: Plantation of xerophytes, i.e., drought-tolerant plants.
2. **PRESERVE EXISTING MATURE TREES:** Mature trees must be preserved / transplanted on site as they require minimum water for maintenance in comparison to freshly planted shrubs or trees.
3. **USE NATIVE SPECIES OVER EXOTIC ONES** : Native plants are those that grow naturally in the local habitat. Hence, they require less water and maintenance.
4. **MINIMIZE LAWN AREA**: Lawn areas in landscape should be minimized as they consume exorbitant amount of water. If lawns are designed, native variety of Indian grass should be used.
5. **PLANTS GROUPED BY WATER NEEDS**: Plants should be grouped into 'hydro zones', clustering together plants with similar water requirements tend to conserve more water.



EFFICIENT IRRIGATION SYSTEMS

An efficient irrigation methods provides water to plants without wastage. By grouping / zoning plants with similar water needs, appropriate irrigation systems can be used for various groups. Two most efficient and most commonly used irrigation systems are drip irrigation and sprinkler system.
Other efficient irrigation systems are furrow irrigation, seepage irrigation, bobble head irrigation etc. Additionally, installing a rain sensor on automatic irrigation systems should be considered to prevent unnecessary watering when it rains.

Drip irrigation system for watering trees and shrubs should be considered as it delivers water directly to plant roots at a low flow rate, avoiding water loss due to runoff.



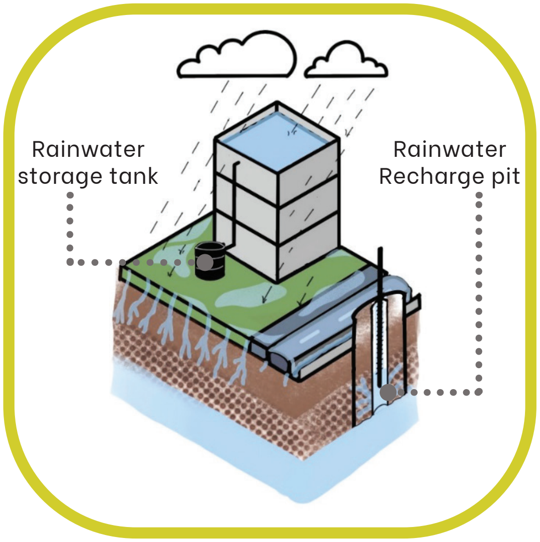
Sprinkler irrigation is the most commonly used method of watering lawns. A properly adjusted sprinkler head should spray large droplets of water instead of a fog of fine mist which is more susceptible to evaporation and wind drift.

4.3 RAINWATER MANAGEMENT

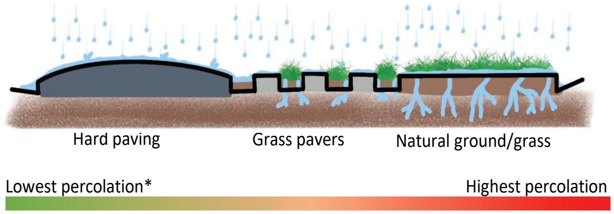
Rainwater is one of the purest freely available forms of freshwater. Rainwater must be harvested and reused in order to meet the increasing water demands, reduce urban floods and recharge groundwater.

HOW TO HARVEST RAIN WATER?

In the process of harvesting rainwater, it can either be used to recharge groundwater table or stored for reuse or a combined approach could be adopted. The following is the methodology to be adopted for harvesting:



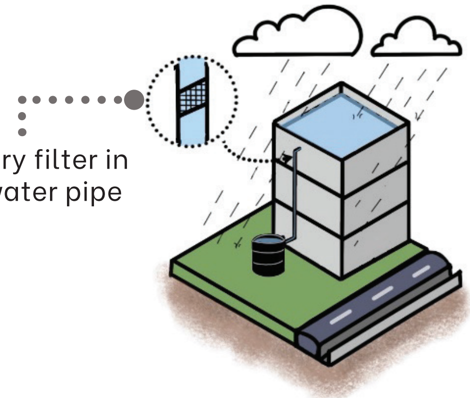
1. **MINIMIZE SURFACE RUNOFF**:
Choose materials whose runoff coefficient (refer Annexure III)is low i.e. they allow water to percolate into the ground.



Types of ground surfaces and levels of percolation

2. **SEGREGATE RAINWATER**:
Rainwater runoff (post first flush) from the roof is cleaner, hence can be stored and reused.
Rainwater runoff from the surfaces can be directed to the recharge pit.

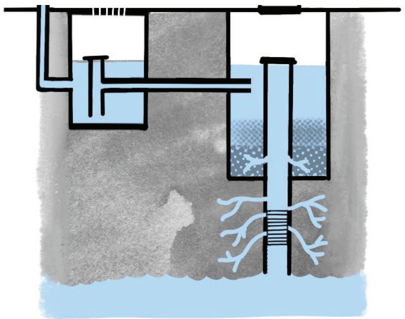
RAINWATER STORAGE



Note:
Raw water tank or fire tank can be used for storing rainwater, hence eliminating the need to install an additional tank for rainwater storage.

While storing rainwater, a primary filter should be used in the rainwater pipe. Further filtration can be done as per the quality of rainwater in the region.
Downpour of the first rain during monsoon should be directed into the storm water drains instead of the rainwater storage tanks as it carries a lot of accumulated dirt from the last season. This can easily be achieved by using a diversion valve.

RAINWATER RECHARGE



Rainwater recharge pit should be connected to a filtration tank like a desilting chamber with a grease trap to segregate oil based impurities before directing the water towards aquifer.

REMEMBER!
Bore depth must be above post monsoon water table to avoid contamination of ground water.

4.4 WASTEWATER MANAGEMENT

Wastewater treatment and reuse is essential to reduce dependency on freshwater sources and meet the increasing water demands. It is also an efficient solution to eliminate effluent waste from entering natural water sources, hence reducing water contamination. This in turn is essential for ensuring clean water availability.

TYPES OF WASTE-WATER IN A HOUSEHOLD

Black water

Components: Urine, Feces, flush water and water from health faucet.

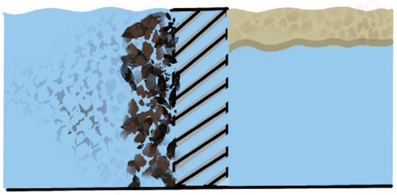
Source: Toilet

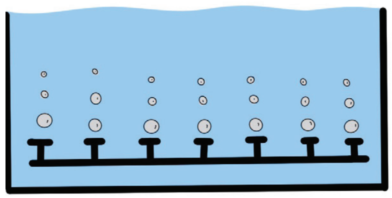
Grey water

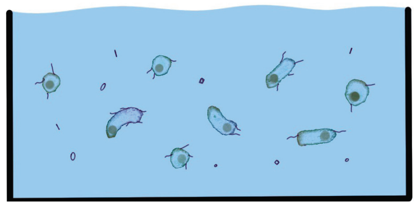
Components: Oil, grease, soap, chemicals, bleach, germs etc.

Source: Bathroom, kitchen and washing area

STAGES OF WASTEWATER TREATMENT







1. The primary stage of any wastewater treatment system is removal of solid, oil and grease. Bar screening and equalization tanks are part of the primary stage.
2. The secondary stage of wastewater treatment involves using water-based microorganisms like bacteria to consume biodegradable soluble contaminants like sugar, fat, detergent and food waste. Aerobic and anaerobic treatment are a part of this stage.
3. The tertiary stage of wastewater treatment includes use of ozonation, UV treatment, activated carbon absorption and chlorination (if required) to remove inorganic harmful compounds like nitrogen, phosphorous and other bacteria and parasites harmful for human health.

DID YOU KNOW?
Grey water is less contaminated than black water and responsible for around 62% of the total building water demand. Therefore, lesser efficiency of filters can treat the available grey water on site and provide the required parameters of treated water as defined by Central Pollution of Control Board (CPCB). Hence, project can install high-efficiency filters, only for 26% of the black water and not for the 100% wastewater generated on site which directly impacts the installation cost of wastewater treatment system. Hence, sewage treatment plant for treating grey and black water should be installed separately.

TYPES OF WASTEWATER TREATMENT SYSTEMS

Wastewater treatment is a combination of physical, chemical, and biological processes. Some different types of wastewater treatment systems are reed bed system, Soil biotechnology, phytorid, outlet zone, DEWATS systems, membrane bioreactor, membrane bed bioreactor, sequencing batch reactor, fluidized aerobic bioreactor and submerged aerobic fixed film process. Details about each wastewater treatment system can be found in Annexure IV.

Table: Guidelines for choosing of grey waste water system for residential buildings[36]

Grey Water Quantity (KL)	Site Area / Appropriate Treatment Option					
	Up to 500sqm	500- 1000sqm	1000-2500sqm	0.5-2.5acre	2.5-5acre	>5acre
0-4	D(C)/SFS/RBS	D(C)/SFS/RBS	GDS/RBS/D(C)	PDS/RBS/ D(C)	PDS/RBS/D(C)	PDS/RBS/D(C)
4-12	D(C)/SFS/RBS	D(C)/SFS/RBS	SFS/RBS/D(C)	SFS/RBS/D(C)	RBS/ABS/D(C)	RBS/ABS/D(C)
12-40	D(C)/SFS/RBS	D(C)/SFS/RBS	RBS/EC/D(C)	RBS/EC/D(C)	RBS/EC/D(C)	RBS/ABS/D(C)
40-80	D(C)/SFS/RBS	D(C)/SFS/RBS	RBS/EC/D(C)	RBS/EC/D(C)	RBS/ABS/ D(UV)	RBS/ABS/D(C)
80-160	EC/D(C)/ D(UV)	EC/D(C)/D(UV)	EC/D(C)/D(UV)	EC/D(C)/ D(UV)	ABS/D(C)/ D(UV)	ABS/D(C)/ D(UV)
160-400	EC/D(C)/ D(UV)	EC/D(C)/D(UV)	EC/D(C)/D(UV)	EC/D(C)/ D(UV)	ABS/D(C)/ D(UV)	ABS/D(C)/ D(UV)
> 400	EC/D(C)/ D(UV)	EC/D(C)/D(UV)	EC/D(C)/D(UV)	EC/D(C)/ D(UV)	ABS/D(C)/ D(UV)	ABS/D(C)/ D(UV)

GDS- Gravity Diversion System, PDS - Pump Diversion System, SFS - Sand Filter System, RBS- Reed bed System, ABS - Aerobic Biological System, EC - Electro Coagulation, D(C) - Disinfection (Chlorine), D(UV) - Disinfection (Ultra Violet), D(O) - Disinfection (ozone), ATS - Advanced Treatment Systems

ABS: Aerobic biological system; ATS: Advanced treatment systems; D(C): Disinfection (chlorine); D(UV): Disinfection (ultraviolet); EC: Electrocoagulation; GDS: Gravity diversion system; PDS: Pump diversion system; RBS: Reed bed system; SFS: Sand filter system

4.5 WATER QUALITY

Impure water use may lead to various health and hygiene issues. Also, some of the water quality parameters if not checked may even result in life-threatening situations. So, it becomes essential that the water being used for various purposes within a project should be fit for its intended use.

SOURCES OF WATER

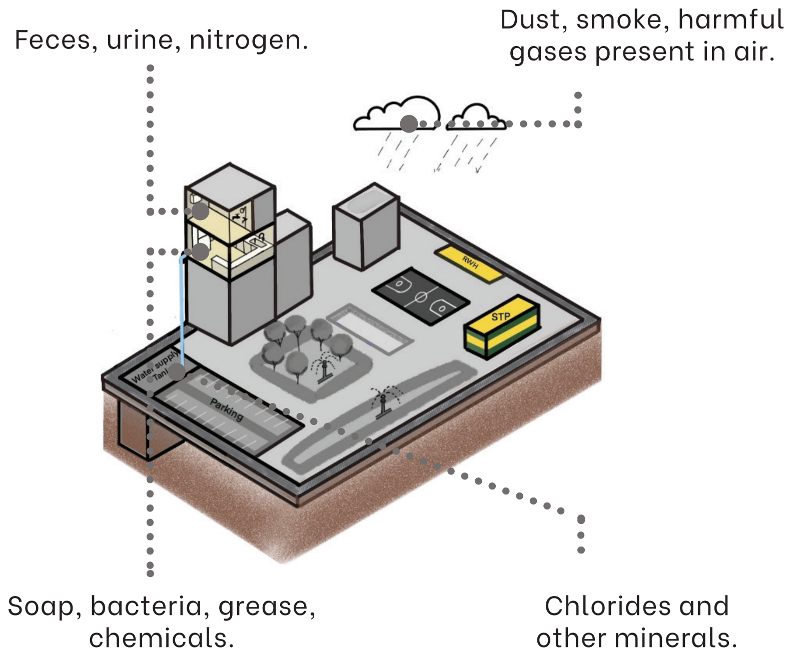
Municipal water

Rainwater

Ground Water / Borewell

Treated Water

TYPES OF POLLUTANTS PRESENT IN WATER



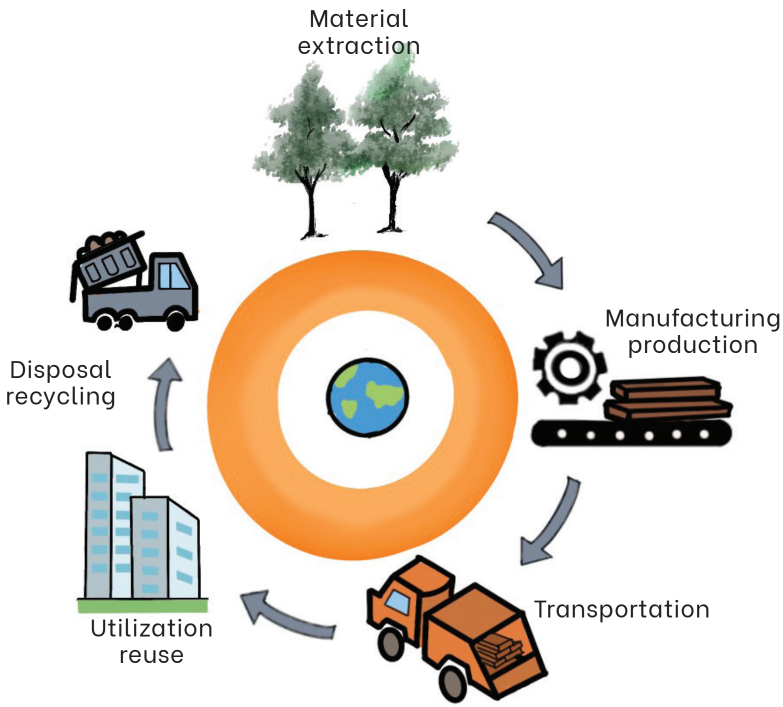
WATER QUALITY STANDARDS

Potable water from bore well, municipal supply or treated rainwater used for drinking must meet BIS (Bureau of India Standards).

Water used for purposes such as flushing, irrigation, HVAC makeup water must meet CPCB standards.

5 SUSTAINABLE BUILDING MATERIALS

Building materials have a significant impact on the environment. During their entire life cycle, their negative environmental impact is due to various reasons as mentioned below. Based on these reasons every material has a global warming potential (GWP) which is assessed by the emissions caused by the material throughout its life cycle.



Stages of the life cycle of building materials

Reasons for negative impact of building materials

Loss of natural resources

Energy intensive

Disposal: Certain materials stay in environment for centuries such as plastic and fiberglass

5.1 ALTERNATIVE MATERIALS

What are Alternative Materials?

These are the materials that have lesser negative impact on the environment. The reduced impact could be due to reasons such as replacement of virgin material by waste materials in their manufacturing, local availability and efficient manufacturing process and easy disposal and decay.

Type of Alternative Materials with Examples:

Renewable

Bamboo, cork, straw

Local

Stones

Salvaged

Timber

Recycled

Fly ash, slag, engineered

Biodegradable

Bamboo, cork

Certified materials*

FSC Wood

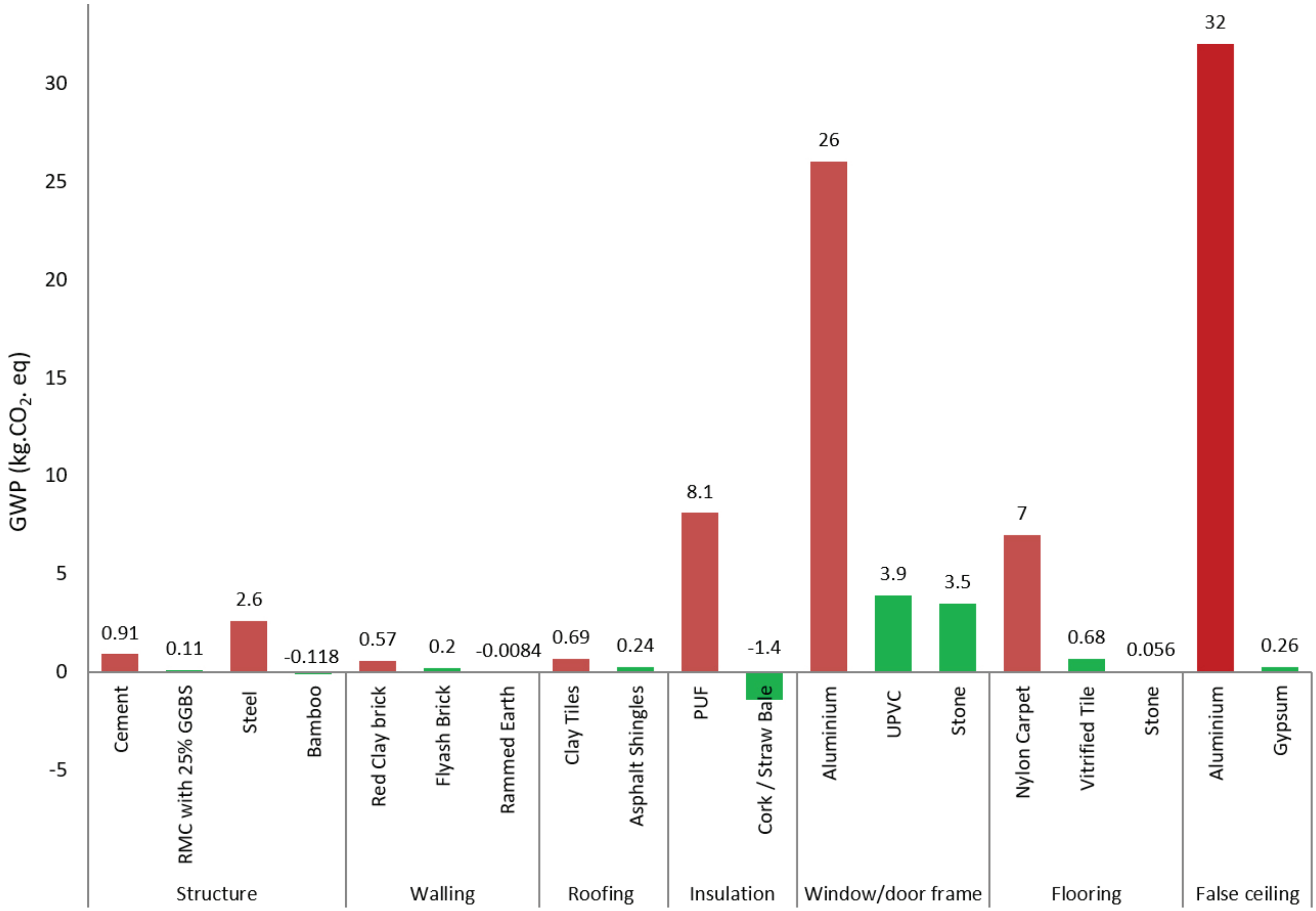
Low Volatile Organic Compound

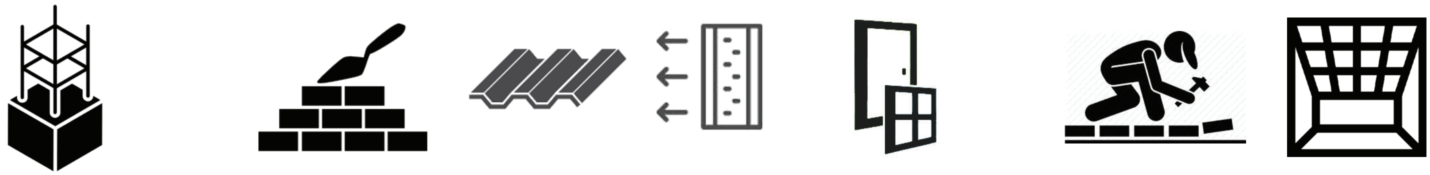
Paints, adhesives, sealants

*Materials certified by competant authorities based on environmental parameters. Includes products such as products with Environment Product Declaration (EPD), analyzed for water footprint as per IS14046

CONVENTIONAL BUILDING VS. ALTERNATIVE CONSTRUCTION MATERIALS

The following graph shows the impact of conventional materials on the environment viz a viz alternative materials in terms of GWP [37, 38]. High GWP is due to high utilization of non renewable natural resource, energy and water, high generation of waste and pollution etc. Negative value indicates that the product sequesters carbon. It is measured in Kg. CO_2 equivalet.





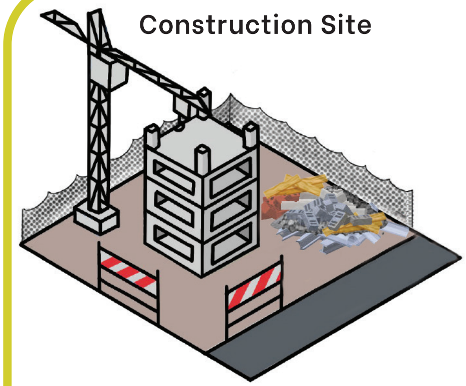
6 SOLID WASTE MANAGEMENT

Solid waste management is a critical issue the world is facing. Most of the waste generated is either dumped in open, later directed to landfills or is burnt. Burning of wastes and creation of landfills contribute towards air, land and water pollution.

In context of buildings, solid waste generated can be broadly categorized into the following:

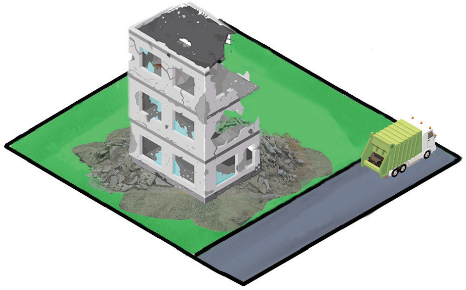
BUILDING CONSTRUCTION & DEMOLITION WASTE	POST OCCUPANCY WASTE

Construction Site



Waste generated during construction

Existing Building



Construction and demolition waste from existnig building

Existing Building

Waste generated by building occupants

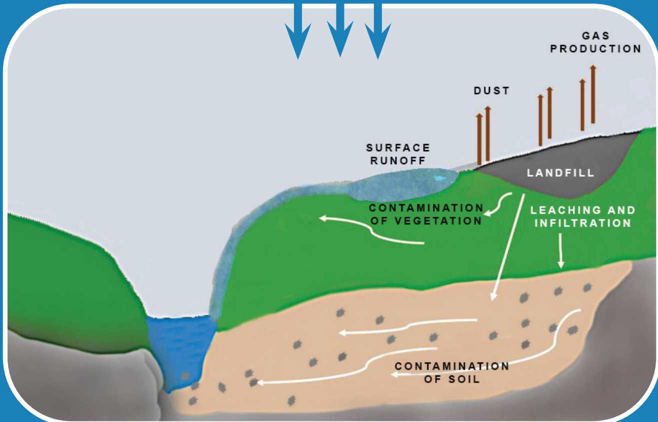
DID YOU KNOW?

Environmental issues of landfills:

1. Greenhouse Gas Emission: Organic mass decomposes to release gases such as methane, CO_2 etc. which are harmful to the environment.

2. Leachate- It's a liquid produced by landfills that contaminate the groundwater and other water sources around.

3. Eutrophication- This is due to ammonia in leachate that causes lack of oxygen for animals in and around the water sources



6.1 CONSTRUCTION & DEMOLITION WASTE MANAGEMENT

Construction and Demolition (C&D) waste is generated during the construction of new projects and retrofitting and demolition of existing projects. Managing C&D waste to maximize recovery of resources can help in:

- Reducing negative environmental impact of buildings
- Reducing demand supply gap

C & D WASTE MANAGEMENT STRATEGIES

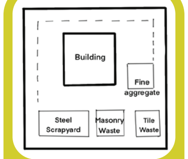
1. Salvage: Materials such as doors, windows, hardware, appliances etc.

2. Reuse: Use of concrete and masonry wastes in back filling and C&D blocks.

3. Recycle: Wood waste such as shuttering material from new development or wooden items from existing structure can be crushed and recycled.

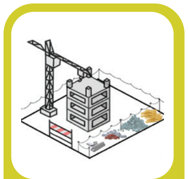
4. Sell/ buy C&D waste

MANAGEMENT PROCESS



Prepare site logistic plan demarcating spaces for construction activities

1



Provision of dedicated storage for segregated waste

2

Adopt strategies of salvage/ reuse/ recycle/ rebuy

3

Sell or dispose the remaining waste

4

TYPES OF C&D WASTE GENERATED AND THEIR REUSE APPLICATIONS

Types of waste	Example	Reuse application
Land clearing	Tree stumps, tree tops	Before cutting, plan preserving or transplant If cut, sell off to wooden material manufacturer
Demolition waste	Concrete, brick, plaster, roofing materials	Can be used in C&D blocks, backfilling, sub-base materials or driveway bedding
	Doors, windows, metals, furniture	Can be salvaged and can either be sold or used for any new construction
	Insulation	Can be used for insulation in new construction
Construction waste	Wood scrap	Can be shredded and recycled into wooden items
	Packaging waste	Can be returned to suppliers
	Concrete, rubble, cement bags	Can be used backfilling, sub-base materials or driveway bedding

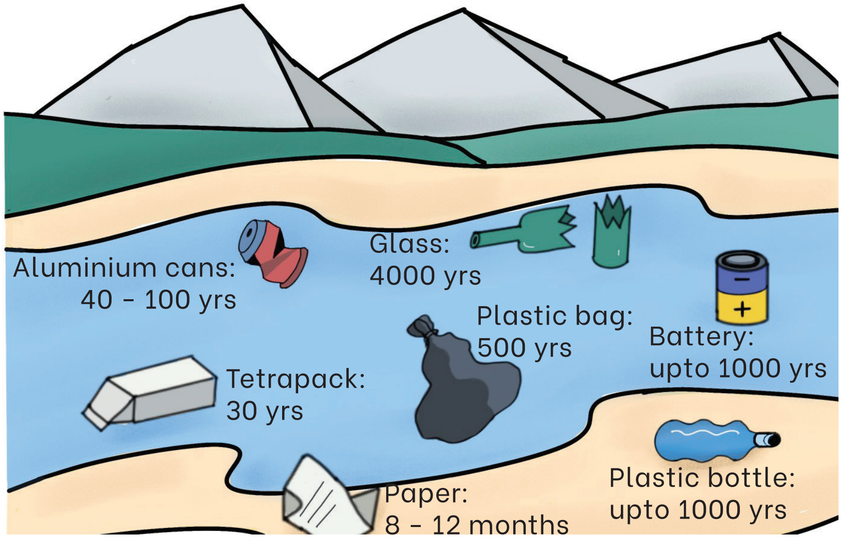
6.2 MUNICIPAL SOLID WASTE MANAGEMENT

Municipal Solid Waste (MSW) that reaches landfill sites without being treated comprise approx. 35 to 50% organic waste, 40 to 45% inert waste and 5 to 15% recyclable waste. If treated efficiently, a significant amount of waste can be converted into resource.

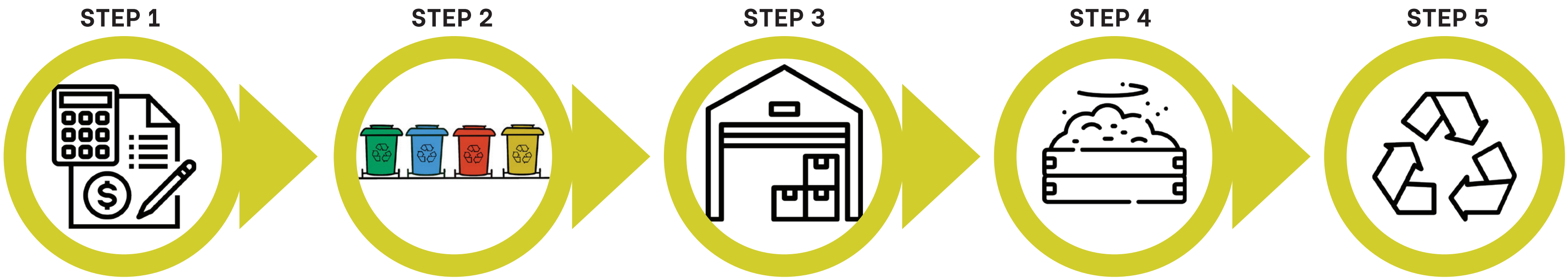
TYPES OF M.S.W. GENERATED FROM RESIDENTIAL BUILDINGS

Wastes	Examples
Organic	Food and landscape waste
Electrical	Batteries, old remotes, telephones, mobiles
Recyclable	Paper, glass, metals, plastics bottles
Non-recylcable	Plastic bags
Soiled	Diapers , sanitary napkins
Hazardous	fluorescent light bulbs, household chemicals & cleaners

TIME FOR DECOMPOSITION OF WASTE [39]



M.S.W. MANAGEMENT PROCESS



Step 1: Estimation
1.1. Residence level
Calculate total waste generated
• Total waste generation to be used is 0.3 to 0.6 kg/capita/day.
• Per day waste generation in the project= Occupancy × total waste generated per capita.
• 40% of this to be considered organic waste.

1.2. Site level
Calculate total waste generated
• Waste generated depends on planted species. Ranges between 32 to 132 gm/m2/year
• Total waste generation to be used is 0.3 to 0.6 kg/capita/day.

Step 2: Segregation at Source
• Provision of multi-coloured labelled dustbins as per estimation at residence and site level.

Step 3: Storage
Provision of central storage area for segregated waste as per estimation.
Regular cleaning of area.

Step 4: Identify and Treat
Recyclable and organic waste should be treated and reused.

Step 5: Dispose
Contract with recycler for disposal of waste

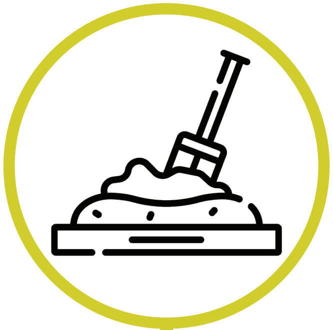
ORGANIC WASTE MANAGEMENT

Organic waste or 'wet waste' is biodegradable in nature and can be easily utilized as a resource with several applications. Since there is no recyclable content in it, it is of no use to rag pickers or recyclers. Thus it is diverted to landfills. To avoid the same, it is wise to segregate and treat it on site itself to convert it into resource and not landfill.

STEP 1: Calculate the total organic waste generated in the project.

STEP 2: Provision of separate bins for organic waste

STEP 3: install waste treatment system based on quantity and affordability



STEP 4: Treat waste as per system specifications

STEP 5: Utilization of resource recovered

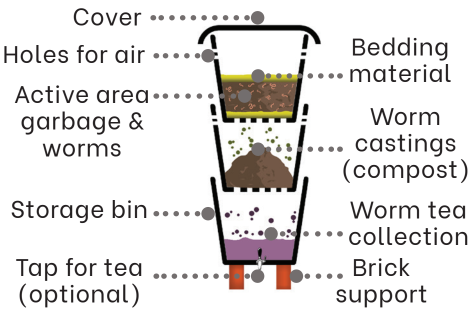
TYPES OF TREATMENT SYSTEMS

1. Composting: Natural process of recycling organic waste
End product: Compost/fertilizer

2. Bio Methanation: Digestion of waste by microorganisms under anaerobic conditions
End product: Bio gas

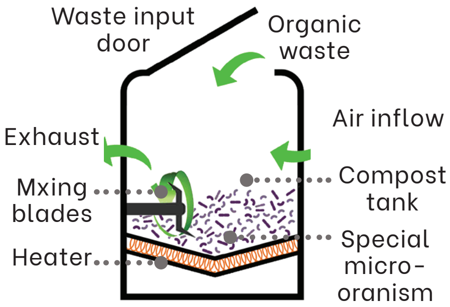
Biological composting: Does 'nt require electricity

Stack system (natural composting)



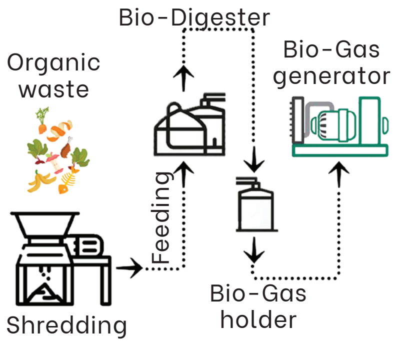
Vermicomposting (worms used for composting)

Mechanical composting: Consumes electricity



Mechanical Composter

Bio-Methanation



Biogas plant

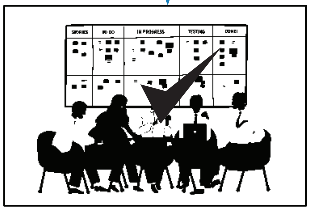
7 SOCIO ECONOMIC STRATEGIES

Buildings have the potential to contribute towards social sustainability. This is achieved by providing liveability requirements to people associated with it during its entire lifecycle. However, certain group of people do not get the basic liveability needs and they offen suffer because of this issue.

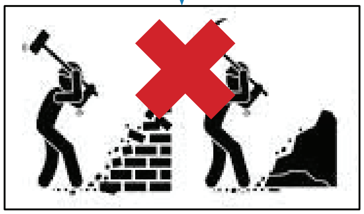
RESIDENTIAL PROJECT

During construction

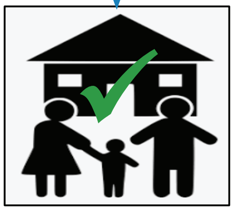
Post occupancy



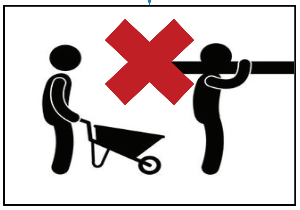
PROJECT MANAGEMENT TEAM



CONSTRUCTION WORKERS



BUILDING OCCUPANTS



SERVICE STAFF

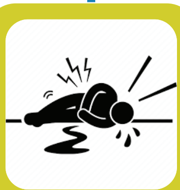
PEOPLE WITH SPECIAL NEEDS

People associated with projects who often meet and do not meet basic liveability requirements

CHALLENGES AT DIFFERENT SOCIO-ECONOMIC LEVELS OF SOCIETY

Construction Workers

Lack of safety measures leading to accidents



No first-aid facilities leading to casualties

Poor living conditions provided on site

Unavailability of clean drinking water and toilets

Service Staff

No resting spaces

People with special needs

Inaccessible built environment

OUTCOMES OF SOCIO-ECONOMIC STRATEGIES

1. Equity in built-environment
2. Improved health and wellness
3. Enhanced productivity leading to cost effectiveness

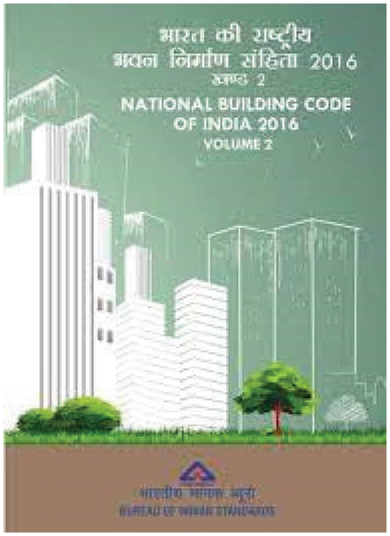
7.1 FACILITIES FOR CONSTRUCTION WORKERS

Safety of construction workers is of utmost importance as the Government of India has rolled out various laws and policies to ensure the same. National Building Code of India has listed all measures to be adopted on construction site to ensure the safety of construction workers. Few of them have been listed below.

RECOMMENDED STRATEGIES TO ENSURE SAFETY AND WELLNESS OF CONSTRUCTION WORKERS

1. PROVISION OF SAFETY EQUIPMENT TO WORKERS

RECOMMENDED CODE



3. HEALTH AND WELLNESS

Drinking Water Facility
Provision of water facility at multiple points
Regular testing of water quality

Toilet Facility
Clean toilet facility with water provision
1 urinal should be provided per 25 males
1 WC per should be provided 15 female

Grocery Store
Provision at the accommodation for basic daily need items.
Clean cooking fuel provision at the accommodation.

2. SAFETY MEASURES ON SITE

Safety Signage & Nets

Safety Barricading

Fire Safety Measures

First-Aid Facilities

5. SAFETY OF CHILDREN IF ACCOMMODATION IS ON CONSTRUCTION SITE

- Children to be restricted from entering the construction site.
- Provision of creche facility

4. ACCOMMODATION

Provision of hutments with daylight and ventilation provision.
Min area/person- 3.6 sq.m.
Min. room height- 2.7 m
Min. no. of lavatories- 1 per 10 persons
Min. no. of bathrooms- 1 per 15 persons
Min. of urinals- 1 per 25 persons
Min. area for kitchen- 0.6 sq.m. /person

7.2 FACILITIES FOR SERVICE STAFF – POST OCCUPANCY

Service staff in an occupied building includes support staff required for the maintenance of individual residences, communities and residential apartment premises. There is a need to ensure safety and comfort of male and female staff members who maintain individual residences and site.

SERVICE STAFF EMPLOYED IN BUILDINGS

SWEEPER

SECURITY GUARD

ELECTRICIAN

DRIVERS

HOUSE HELP

CAR CLEANER

PLUMBER

GARDENER

RECOMMENDED STRATEGIES TO ENSURE SAFETY AND WELLNESS OF SERVICE STAFF

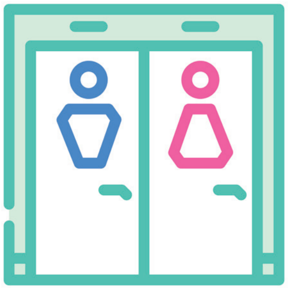
PROVISION OF SPACE FOR RESTING

- Separate rooms should be provided for male & female workers.
- Area of habitable room should not be less than 3.6 m².
- Height should be minimum 2.7 m.
- Window should be provided.

PROVISION OF DRINKING WATER FACILITY

- Clean drinking water facility should be provided.
- Regular testing should be done for water quality.

PROVISION OF TOILETS



- Clean toilet facility with water provision.
- 1 urinal should be provided per 25 males.
- 1 WC should be provided per 15 female.

7.3 DESIGN FOR UNIVERSAL ACCESSIBILITY

In order to ensure social sustainability on site, measures that make the built environment barrier free and accessible to all, including people with disabilities and elderly people, should be adopted. However, the way most of the buildings and sites are developed, accessibility becomes a challenge for people with different needs that leaves them with low self esteem and confidence.

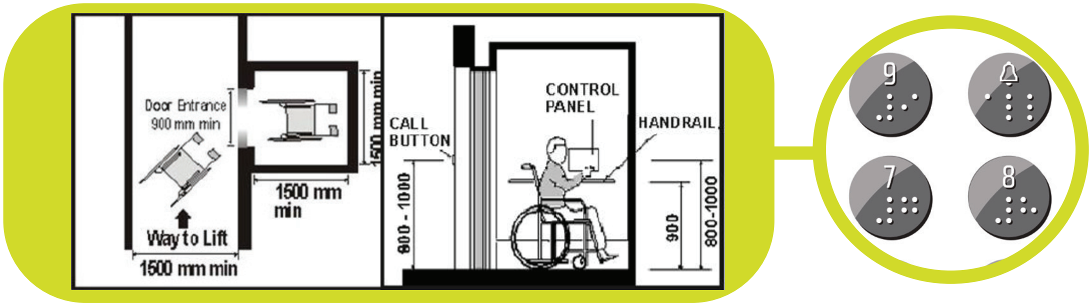
Pregnant ladies

Elderly people

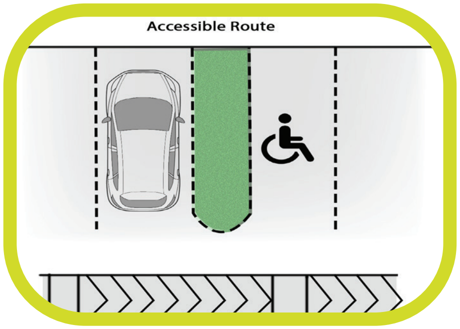
Children

Differently abled people

STRATEGIES FOR UNIVERSAL ACCESSIBILITY



Size and placement of lift accessories should be in accordance to NBC. Lifts should have audio assistance, braille buttons and railings for specially abled people.



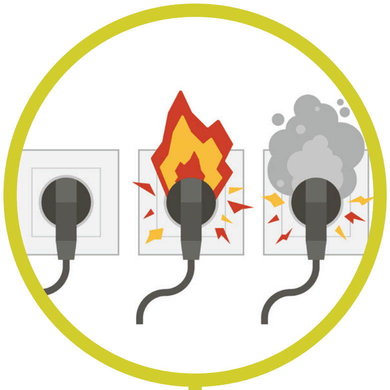
Parking spots for specially abled people should be provided at locations in close proximity to the entrance of the building blocks.

Ramps with dual railings, lifts with audio assistance and braille buttons, parking sports and toilets for specially abled people should be provided on site.

Layout and spacing in the toilet for specially abled people should be in accordance to NBC.

8 PERFORMANCE METERING AND MONITORING

Long lasting benefits of a green building can be achieved only when the ‘operation and maintenance’ protocol of the building is designed and implemented. A few problems faced in buildings in absence of monitoring are:



Poor and inappropriate usage of systems

Regular system breakdown

High energy and water bills

Occupant discomfort due to system inefficiency

HOW TO IMPROVE BUILDING PERFORMANCE

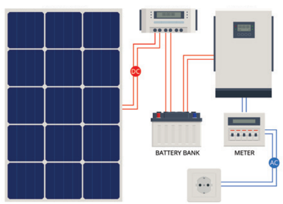
The above challengecan be easily handled by following solutions:

Commissioning of systems

Benefits

- Helps in making sure that systems perform as per the design intent and rated efficiencies
- Helps in creating robust O&M protocols

Metering and monitoring



Benefits

- Better management of resources.
- Optimized utility consumption
- Highlights improvement opportunities

Operation and Maintenance

Benefits

- Helps in smooth maintenance process.
- Prevents failure
- Increases system life.
- Increased occupant comfort

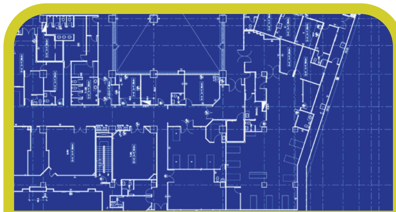
8.1 COMMISSIONING

Commissioning is a systematic process of ensuring that all building systems perform interactively according to, the design intent, and the owner's operational needs.

HOW IS COMMISSIONING PERFORMED?

Commissioning spans across the entire design and construction process. This ideally begins at the design phase, with the engagement of a commissioning provider. The commissioning provider is responsible for inspecting the building systems and components during construction. When the project is near completion, the provider and contractor conduct rigorous performance tests and submit outcome reports as per findings.

STAGES OF COMMISSIONING



PRE-DESIGN PHASE

- Select a commision lead
- Conduct a commissioning meeting
- **Begin developing ower's Project requirements**
- **Develop initial Commissioning Plan Outline**

DESIGN PHASE

- Perform commissioning focused design review
- Update Commmissioning Plan
- **Develop commissioning requirements for the specification**
- Begin planning for verification checklists,functional tests,System Manual,and training requirements

CONSTRUCTION PHASE

- Construction Phase kick-off meeting
- Review submittals, monitor development of Shop and Coordination drawings
- Review O&M Manuals
- Perform ongoingconstruction observation
- **Perform verification checks**
- Perform diagnostics monitoring
- **Perform functional testing**
- **Develop Commissioning Report and Systems Manual**
- Develop Recommissioning Plans
- Verify and review training of owner's staff

OCCUPANCY AND OPERATIONS PHASE

- Resolve outstanding commissioning issues
- Perform seasonal/ deferred testing
- Perform near warranty end review

- **Owner's requirements** - describes design intent with performance criteria and goals.
- **Commissioning plan** - includes management strategy and list of all features and systems.
- **Design review** – includes system specifications with owners intent.
- **Pre-functional checklists** - includes for specifications of equipment identified in the commissioning plan.
- **Functional performance test procedures and checklists** - Develop functional performance test procedures and performance criteria verification checklists for each of the systems.
- **Commissioning report** – Consists of results of pre-functional checklists, installation observation, start-up and checkout for each system as per commissioning plan.

8.2 METERING AND MONITORING

Metering and monitoring helps users to assess the utility consumption that is often coupled to pricing charges per unit consumed. This process consist of three major steps

Measuring of utility consumption → Evaluating consumption patterns → Reducing resource consumption based on consumption patterns

WHERE TO INSTALL METERS

Metering can be implemented at two levels. The basic metering is done at source level to measure important end utility use. Advance metering is performed at each individual end use of resource such as to track, manage and optimize consumption.

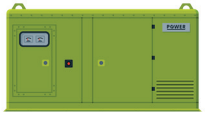
Basic Energy Metering

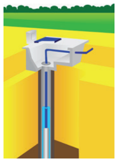
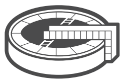
- Renewable Energy
- Utility grid
- Diesel/gas Gen set

Water

- Municipal supply
- Bore well
- STP outlet
- Rainwater reuse

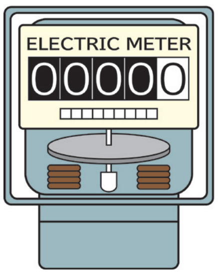





TYPES OF COMMONLY USED ENERGY METERS

- Electromechanical induction type
- Electronic Energy Meter



TYPES OF COMMONLY USED WATER METERS

- Displacement water meters
- Velocity water meters
- Electromagnetic meters
- Ultrasonic meters

SMART METERING AND BUILDING MANAGEMENT SYSTEM

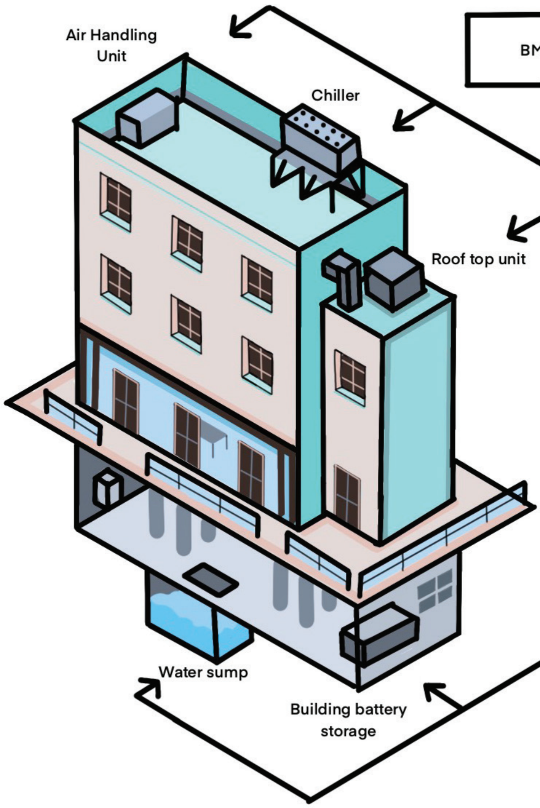
Smart metering is a highly automated process which incorporates distribution, data processing and storage to meters in a cost-efficient way to improve the functionality, reliability, and robustness of metering.

FEATURES OF SMART METERING SYSTEMS

- Automatic processing, transfer, management, and utilization of metering data
- Better control on utilities operation.
- Provides real time resource consumption information.

WHAT IS A BMS?

Building management system is a type of smart metering system.
A BMS connects the HVAC and different building equipment to work as one integrated unit. Ideally, they should centralize operations and make data easier to visualize using a user interface or console.



A Building Management System is a computer-based smart metering system installed in buildings to manage and monitor equipment such as air-conditioning, heating, ventilation, lighting, power systems, security devices, IoT sensors, energy and water meters.

8.3 OPERATIONS AND MAINTENANCE

Effective Operation and Maintenance is one of the most cost-effective methods for ensuring reliability, safety, and energy efficiency. Operation and maintenance activities are crucial for organizations wanting to optimize asset management.

Types of Maintenance

- Preventive Maintenance
- Breakdown Maintenance
- Shutdown Maintenance
- Corrective Maintenance
- Emergency Maintenance

What is O&M manual ?

The operation and maintenance (O&M) manual is a detailed document containing the instructions to manage and maintain a facility such as. These manuals should be handed over to the project team by the system manufacturers.

The manual consist of following main components:

- Asset register with technical specifications
- Regular operating characteristics of the machine.
- Detailed engineering drawings of the equipment and components.
- SOPs for routine maintenance and other daily operations.
- Recommended maintenance schedules, troubleshooting procedures

GUIDELINE

How to perform O&M ?

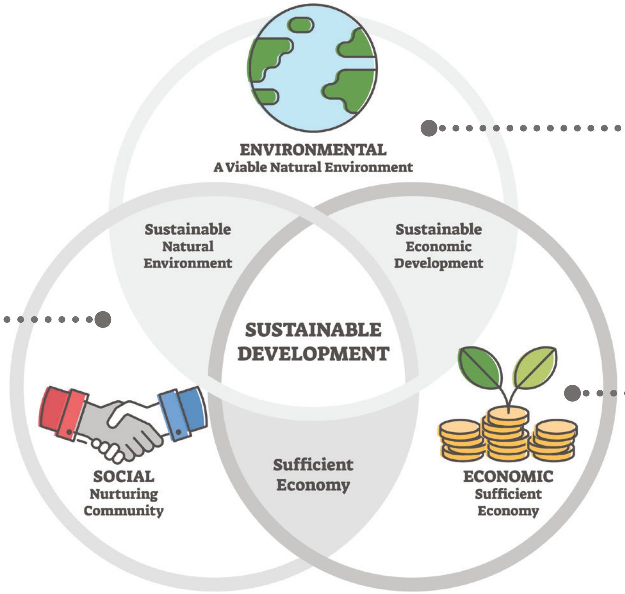
To ensure that the benefits from building commissioning performed during construction persist over time, good O&M practices must be in place. Some of these practices includes:

- Implementing a preventive maintenance programme for all building equipment and systems.
- Reviewing monthly utility bills for unexpected changes in building energy /water use.
- Tracking all scheduled or unscheduled maintenance.

Remember !
The requirements of O&M will vary for a each user. As the number of services, variety, and complexity of facilities increase, the complexities of O&M activities increases.

9 INNOVATION

Innovation accounts for any idea that pushes the boundaries of the conventional norms of green building design and raises the sustainability quotient of the project. Such ideas are crucial to encourage the green building fraternity to endeavour to expand the realms of sustainable design, including its social, economic and environmental aspects.



Environmental sustainability: Promoting ways of development that ensure that there is minimum harm to the environment and its safe for the future generations.

Social sustainability: Creating an inclusive environment which promotes the development of all members of the society.

Economic sustainability: Ensuring that the growth of the economic sectors goes hand in hand with the environment.

INNOVATION STRATEGIES

PROVIDE GENDER NEUTRAL TOILETS

To promote inclusivity for all genders and help make a project socially sustainable.

MONITOR AIR QUALITY DURING CONSTRUCTION

To spread awareness about the pollution caused due to construction activities and inspires people to find solutions to control the same.

REUSE CONCRETE WASTE

Reusing concrete waste for backfilling on site or to produce new concrete products, to minimize wastage and save construction cost.

NET ZERO ENERGY & WATER

Net positive energy / water projects are self sufficient and do not require energy / water from outside the site by effectively using passive and active green building strategies.

INVOLVE A GREEN BUILDING EXPERT

To ensure effective and smooth implementation of green building strategies in any project.

USE GREEN CLEANING PRODUCTS

Green cleaning products should be used instead of chemical based cleaning products that often contain toxic substances that harm the human health and the environment.

ANNEXURE I

Table 1: List of approvals/sanction and clearances

The prescribed list is indicative and it is not exhaustive.	
Type of Approval/Approving Authority	**Stage of Project**
Approvals from local body/development authority (from either a city development authority or its equivalent)	Project feasibility/pre-sanction stage
Land use plan approval (from either a city development authority or its equivalent)	Project feasibility/pre-sanction stage
Approval for change in land use (from either a city development authority or its equivalent)	Project feasibility/pre-sanction stage
NOC for construction/augmentation (from either a city development authority or its equivalent)	Project feasibility/pre-sanction stage
Relaxation in respect of density/ground coverage/floor area ratio/setbacks/height	Project feasibility/pre-sanction stage
Approval from the AAI	Project feasibility/pre-sanction stage
NOC (legal document) is required for height clearance (from AAI)	Project feasibility/pre-sanction stage
NOC from a Coastal Zone Management Authority	Project feasibility/pre-sanction stage
Local body approval (from either a city development authority or its equivalent)	Sanction stage–layout plan/local area plan/ urban design plan
Approval from National Monuments Authority/ Archaeological Survey of India	Sanction stage–layout plan/local area plan/ urban design plan
Approval from Tree Authority Committee/Forest Committee	Sanction stage–layout plan/local area plan/ urban design plan
Approval from HCC	Sanction stage–layout plan/local area plan/ urban design plan
Approval from Railway Authority/Port Trust/Defence	Sanction stage–layout plan/local area plan/ urban design plan
Approval from road-owning agency (Municipal Corporation of Greater Mumbai, Public Works Department, National Highways Authority of India)	Sanction stage–layout plan/local area plan/ urban design plan
Approval from Traffic and Coordination Department (Municipal)	Sanction stage–layout plan/local area plan/ urban design plan
Approval from the Chief Fire Officer/Fire NOC	Sanction stage–layout plan/local area plan/ urban design plan

Approval from the Chief Controller of Explosives	Sanction stage–layout plan/local area plan/ urban design plan
Approval from the Chief Inspector of Factories	Sanction stage–layout plan/local area plan/ urban design plan
Environmental clearance from Ministry of Environment, Forest and Climate Change	Sanction stage–layout plan/local area plan/ urban design plan
Approval from the Survey and Valuation Department	Sanction stage–layout plan/local area plan/ urban design plan
Approval from the Central Vista Committee	Sanction stage–layout plan/local area plan/ urban design plan
Approval from either Delhi Metro Rail Corporation or its equivalent	Sanction stage–layout plan/local area plan/ urban design plan
Approval from either Delhi Urban Art Commission or its equivalent	Sanction stage–layout plan/local area plan/ urban design plan
Approval from local body/development authority	Sanction/building permit stage
Approval from power distributing/supply agency	Sanction/building permit stage
Approval from water supply agency	Sanction/building permit stage
Approval from storm water/drainage/sewerage department	Sanction/building permit stage
Approval from Central Ground Water Authority	Construction stage
Intimation to Location Authority	Construction stage
Plinth level notice	Construction stage
Completion-cum-Occupancy certificate from local body	Completion-cum-Occupancy stage certificate
Approval/NOC from lift inspector	Completion-cum-Occupancy stage certificate

Table 2: Surface colour and absorptivity[40]

Category	Light	Medium	Dark	Black
Absorptivity Factor	<0.5	0.5 - 0.7	0.7-0.9	>0.9
Colors	White	Dark red	Brown	Black
	cream	Light green	Dark green	Dark brown
		Orange	Light blue	Vivid blue
		Light red		Dark blue

Table 3: Surface finishes and their properties

Building Element Surface	Absorptance (solar radiation)	Emissivity (thermal radiation)
Lime sand stone, gray	0.6	0.96
Concrete, smooth	0.55	0.96
Brick facing, red	0.54	0.93
Aluminium, raw	0.2	0.05
Aluminium anodised	0.33	0.92
Plaster, white	0.21	0.97
Plaster, gray, blue	0.65	0.97
Glass	0.08	0.88
Paint, White	0.25	0.95

Table 4: Thermal properties of building and insulating materials[41]

Type of Materials	Density	Thermal Conductivity	Specific heat capacity
Building Materials			
Burnt brick	1820	0.811	0.88
Mud Brick	1731	0.750	0.88
RCC	2288	1.58	0.88
Lime concrete	1646	0.730	0.88
Mud Phuska	1622	0.519	0.88
Cement mortar	1648	0.719	0.92
Cement plaster	1762	0.721	0.84
Gypsum plaster	1120	0.512	0.96
GI sheet	7520	61.06	0.50
Plywood	640	0.174	1 .76
Glass	2350	0.814	0.814
Insulating Materials			
Expanded polystyrene	16.0	0.038	1.34
Rock wool (unbonded)	92.0	0.047	0.84
Mineral wool (unbonded)	73.5	0.030	0.92
Glass wool (unbonded)	69.0	0.043	0.92
Particle Board	750.0	0.098	1.30
Jute Fiber	329.0	0.067	1.09
Rice Husk	120.0	0.051	1.00

Table 5: Run-off coefficient of different surface finishes[42]

Surface Type	Runoff coefficient
Roof Catchment	
Tiles	0.8-0.9
Corrugated Metal Sheets	0.7-0.9
Concrete	0.7-0.95
Ground Surface Covering	
Parks, cemeteries	0.1 – 0.25
Playgrounds	0.2 – 0.35
Unimproved land areas(Soil)	0.1 – 0.3
Rocky material catchment	0.2 - 0.5
Asphaltic or concrete pavement/Kota paving	0.7 – 0.95
Brick pavement	0.7 – 0.85
Gravel	0.75
Lawns, sandy soil having slopes	
Flat 2%	0.05 – 0.10
Average 2 – 7%	0.1 – 0.15
Steep 7%	0.15 – 0.2
Lawns, clayey soil having slopes	
Flat 2%	0.13 – 0.17
Average 2 – 7%	0.18 – 0.22
Steep 7%	0.25 – 0.35
Vegetation	
Vegetation (1%- 3%)	0.2
Vegetation (3%-10%)	0.25
Vegetation (>10%)	0.3

Table 6:Description of grey water treatment system

Treatment Option	Description	Advantages	Disadvantages
Gravity diversion system	It directs untreated grey water typically from laundry or bathroom sinks to a subsurface garden system, minimizing human contact with the grey water	• Simple manual operation • Very low maintenance (periodic manual screen cleaning) • Ability to divert grey water for immediate reuse • Very low capital and operating cost	• Cannot store without risk of odour and other problems • Does not kill or reduce micro-organisms (pathogens) present • Reuse application limited to immediate subsurface irrigation only
Pump diversion system	Similar to above but rather relying on gravity, fitted with an effluent pump, which pumps the grey water to a subsurface irrigation area	• » Simple operation • » Low maintenance • » Ability to divert grey water for immediate reuse • » Only pump installation and operation cost	• Cannot store without risk of odour and other problems • Does not kill or reduce microorganisms (pathogens) present
Sand filter system	Consists beds of sand or coarse bark or mulch, which trap and absorb contaminants as the grey water flows through it. Based on the design, can have two treatments functions, which involve physical particulate separation and adsorption/bio-degradation of soluble, particulate organic contaminants from grey water	• Simple operation • Low maintenance • Some biological Treatment provided, facilitating limited duration storage and application options • Low operation cost	• Inherently do not provide biological treatment, requires low application rates or recirculation • Low ability to adapt to • varying characteristics • Moderate capital cost • Requires app. 1sft of land area/gallon/day application • Reduces pathogens but not eliminates them • Subject to clogging and • flooding if overloaded

Table 6:Description of grey water treatment system

Treatment Option	Description	Advantages	Disadvantages
Reed bed system	Comprises a number of unit processes combined into a single operation. It takes care of primary sedimentation, biological treatment, final sedimentation, sludge digestion odour control. Its components include a treatment tank, filling material, microorganisms, and fungi	• Natural system resembles a garden and attracts birds, etc. • Low capital, O&M • costs • Simple, long lasting • Little or no maintenance • Easy to operate, • does not need skilled operators • No addition of • Chemicals • Robust process • withstands shock loads • No sludge production	• Requires a fall of at least 1.5m to provide good treatment • High permanent space required • Requires 1sqm /person. • Sensitive to hydraulic • loading • Sand grading, bed sizing critical to avoid blockage • Maintenance, supervision for the first two years
Aerobic biological Treatment system	Results in a typically higher effluent quality than singlepass slow sand filtration. Systems typically followed by a clarification stage to remove suspended bacteria, and may be preceded by a septic tank to settle solids, remove oils and grease	• Potential for high degree of biological • treatment • Less land area required than biological and filter systems • High degree of operations flexibility to handle varying grey water strengths/flows	• Complex operational requirements • High capital and operating costs • Greater level of operation and maintenance required

Table 6:Description of grey water treatment system

Treatment Option	Description	Advantages	Disadvantages
Electro coagulation	Involves adding coagulating metal ions using electrodes. These ions coagulate contaminants in water, similar to coagulating chemicals such as alum and ferric chloride, enabling them to be more easily removed by settling or floating	• Not biological Treatment therefore not necessarily adversely affected by chemicals • Typically less land area required compared to biological treatment	• Complex operational requirements • High capital costs • High operation costs for power and placement of electrodes • Greater level of operation and maintenance required
Disinfection chlorine	The most common and simplest method of disinfection chlorination, usually achieved in grey water systems using sodium hypochlorite 'pucks' similar to that used in disinfecting swimming pool water	• Limited operator skill level required • Highly effective if • properly designed and operated • Low capital and • operating costs • Provides a residual • disinfectant to ensure reuse during prolonged storage	• Chlorine reacts with residual organic organisms to form potential carcinogens • Chemical handling requirements • Need for frequent chemical supply
Disinfection ozone	Ozone is another means of chemical disinfection, typically generated on-site using a device that applies a high voltage potential to air, and bubbling the ozonated air through the treated grey water	• Limited operator skill level required • No chemical storage handling required (ozone generated on-site) • Eliminates colour and precipitates residual contaminants	• High operating cost, attention, electricity than chlorination systems • High capital cost in comparison with chlorination and UV systems • No disinfection residual • Needs good ventilation

Table 6:Description of grey water treatment system

Treatment Option	Description	Advantages	Disadvantages
Disinfection ultraViolet	Disinfection using ultraviolet light is becoming increasingly popular, as no chemicals are required	• Low operator skill level required • No chemical storage and handling requirement • No off-gas or chemicals to handle	• Disinfection efficiency affected by variations in organic content of grey water, flow, and colour • Adversely affected by particulates present in the treated grey water • High operating costs than chlorination systems • No disinfection residual
Advanced treatment system	These systems are adopted in a number of applications in countries such as Australia, New Zealand, Singapore, but still not being adopted in India. These include systems that physically capture/filter our solid from grey water Streams prior to its reuse and will require ongoing householder maintenance to regularly clean filters	• High quality of treated water is achieved • Can be used for toilet flushing, all other non-potable uses • By using this system about 65% of potable water use can be saved • Portable system can be easily replaced or retrofitted	• Not still being introduced in the Indian market • High capital and operation costs • Requires regular maintenance and supervision

Thermal Capacity: “The thermal capacity of a body is the heat necessary to raise the temperature of the body by one degree.”

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